NELLCOR

SERVICE MANUAL

NPB-190 Pulse Oximeter

MALLINCKRODT

Caution: Federal law (U.S.) restricts this device to sale by or on the order of a physician.

To contact Mallinckrodt's representative: In the United States, call 1.800.635.5267 or 314.654.2000; outside of the United States, call your local Mallinckrodt representative.

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SECTION 1: INTRODUCTION

1.1 Manual Overview
1.2 NPB-190 Pulse Oximeter Description
1.3 Power-On Self Test
1.4 Related Documents

1.1 MANUAL OVERVIEW

This manual contains information for servicing the Nellcor model NPB-190 Pulse Oximeter. Only qualified service personnel should service this product. Before servicing the NPB-190, read the operator's manual carefully for a thorough understanding of operation.

Warning: Explosion hazard. Do not use the NPB-190 pulse oximeter in the presence of flammable anesthetics.

1.2 NPB-190 PULSE OXIMETER DESCRIPTION

The Nellcor NPB-190 portable pulse oximeter is intended for continuous, noninvasive measurement of functional oxygen saturation of arterial hemoglobin (SpO_2), and pulse rate (measured by SpO_2 sensor).

The monitor is intended for use on adult, pediatric, and neonatal patients in all hospital-type facilities and in the home environment. It may be used during intra-hospital transport when powered by its internal battery.

Digital displays are provided for oxygen saturation and pulse rate, and a 10-segment LED bar indicates pulse amplitude. High and low alarm limits for saturation and pulse rate can be adjusted by the operator. The NPB-190 can operate on AC or a rechargeable internal battery power. The controls and indicators for the NPB-190 are illustrated in Figures 1-1 and 1-2.

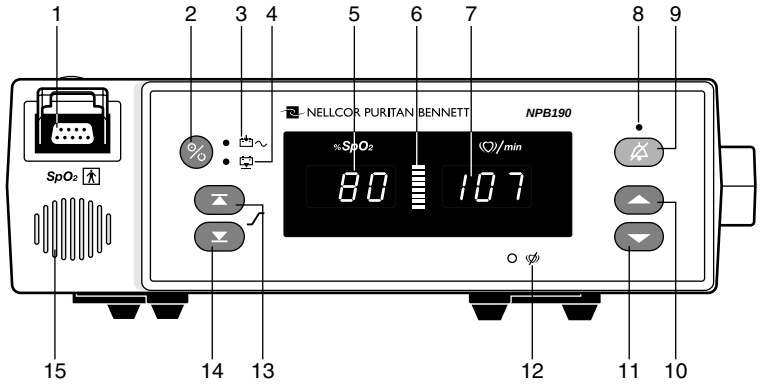


Figure 1-1: NPB-190 Front Panel

1. SpO2 Sensor Port
2. Power On/Standby Button
3. AC/Battery Charging Indicator
4. Low Battery Indicator
5. %SpO2 Display
6. Pulse Amplitude Indicator
7. Pulse **B**eats **p**er **M**inute Display
8. Alarm Silence Indicator
9. Alarm Silence Button
10. Adjust Up Button
11. Adjust Down Button
12. Pulse Search Indicator
13. Upper Alarm Limit Button
14. Lower Alarm Limit Button
15. Speaker

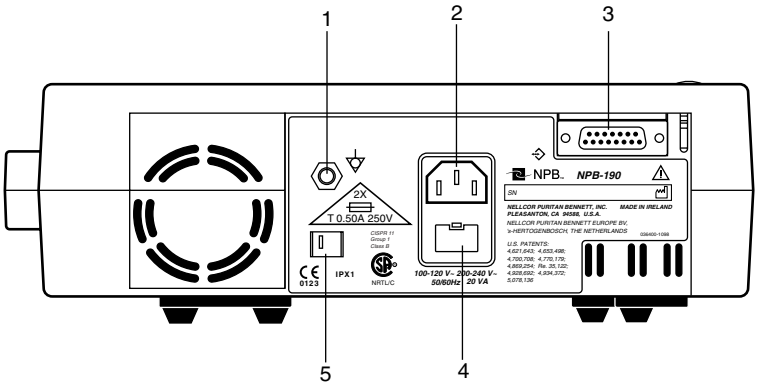


Figure 1-2: NPB-190 Rear Panel

1. Equipotential Terminal
2. AC Connector
3. Serial Port
4. Fuse Drawer
5. Voltage Selector Switch

1.3 POWER-ON SELF TEST

When the NPB-190 is turned on it will perform a POST (Power On Self Test). During POST the following sequence should occur:

- All indicator lights illuminate
- All segments of the numeric digits light
- All segments of the Pulse Amplitude Display light

Upon completion of the POST display test, the software versions will be displayed for approximately 2 seconds. Two versions are displayed:

- The first version is indicated by the numeral "1" in the leftmost segment of the %SpO_2 display. The series of digits and decimal points displayed to the right of the "1" represent the main processor software version.

- The second version is indicated by the numeral "2" in the leftmost segment of the %SpO_2 display. The number(s) appearing to the right of the "2" represent the subprocessor software version.

The software version numbers are often needed when calling Mallinckrodt's Technical Services Department or your local Mallinckrodt representative for technical assistance. Record the numbers and have them available prior to requesting technical assistance.

Upon successful completion of POST, the NPB-190 sounds a 1-second tone indicating that the monitor has passed the test.

If the start-up sequence is not completed as described above do not use the monitor.

1.4 RELATED DOCUMENTS

To perform test and troubleshooting procedures and to understand the principles of operation and circuit analysis sections of this manual, you must know how to operate the monitor. Refer to the NPB-190 operator's manual. To understand the various Nellcor sensors that work with the monitor, refer to the individual sensor directions for use.

SECTION 2: ROUTINE MAINTENANCE

2.1 Cleaning
2.2 Periodic Safety and Functional Checks
2.3 Battery

2.1 CLEANING

Caution: Do not immerse the NPB-190 or its accessories in liquid or clean with caustic or abrasive cleaners. Do not spray or pour any liquid on the monitor or its accessories.

To clean the NPB-190, dampen a cloth with a commercial, nonabrasive cleaner and wipe the exterior surfaces lightly. Do not allow any liquids to come in contact with the power connector, fuse holder, or switches. Do not allow any liquids to penetrate connectors or openings in the instrument cover. Wipe sensor cables with a damp cloth. For sensors, follow the individual directions for use.

2.2 PERIODIC SAFETY AND FUNCTIONAL CHECKS

The following checks should be performed at least every 2 years by a qualified service technician:

1. Inspect the exterior of the NPB-190 for damage.

2. Inspect safety labels for legibility. If the labels are not legible, contact Mallinckrodt's Technical Services Department or your local Mallinckrodt representative.

3. Verify that the unit performs properly as described in paragraph 3.3.

4. Perform the electrical safety tests detailed in paragraph 3.4. If the unit fails these electrical safety tests, do not attempt to repair.

5. Inspect the fuses in the Power Entry Module for proper value and rating. The fuses are slow blow, 0.5 amp, and 250 volt.

2.3 BATTERY

Mallinckrodt recommends replacing the instrument battery every 2 years. When the NPB-190 is going to be stored for 3 months or more remove the battery. To replace or remove the battery, refer to Section 6, *Disassembly Guide*.

If the NPB-190 has been stored for more than 30 days, charge the battery as described in paragraph 3.3.1. A fully discharged battery requires 14 hours to receive a full charge. The battery is being charged anytime the instrument is plugged into AC.

SECTION 3: PERFORMANCE VERIFICATION

3.1 Introduction
3.2 Equipment Needed
3.3 Performance Tests
3.4 Safety Tests

3.1 INTRODUCTION

This section discusses the tests used to verify performance following repairs or during routine maintenance. All tests can be performed without removing the NPB-190 cover. All tests except the battery charge and battery performance tests must be performed as the last operation before the monitor is returned to the user.

If the NPB-190 fails to perform as specified in any test, repairs must be made to correct the problem before the monitor is returned to the user.

3.2 EQUIPMENT NEEDED

Equipment	**Description**
Digital multimeter (DMM)	Fluke Model 87 or equivalent
Durasensor oxygen transducer	DS-100A
Oxisensor II oxygen transducer	D-25
Pulse oximeter tester	SRC-2
Safety analyzer	Must meet current AAMI specifications
Sensor extension cable	EC-4 or EC-8
Serial interface cable	EIA-232 cable (optional)
Stopwatch	Manual or electronic

3.3 PERFORMANCE TESTS

The battery charge procedure should be performed before monitor repairs whenever possible. It should also be performed before and after performing the battery performance test (paragraph 3.3.2).

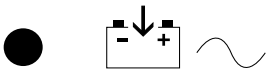
Note: This section is written using Mallinckrodt factory-set defaults. If your institution has preconfigured custom defaults, those values will be displayed. Factory defaults can be reset using the configuration procedure described in paragraph 4.3.3.

3.3.1 Battery Charge

Perform the following procedure to fully charge the battery.

1. Connect the monitor to an AC power source.

2. Verify that the monitor is off and that the AC Power/Battery Charging indicator is lit.



3. Charge the battery for at least 14 hours.

3.3.2 Performance Tests

The power-up performance tests (3.3.2.1 and 3.3.2.2) verify the following monitor functions:

- Power-On Self-Test
- Factory Power-On Defaults and Alarm Limit Ranges

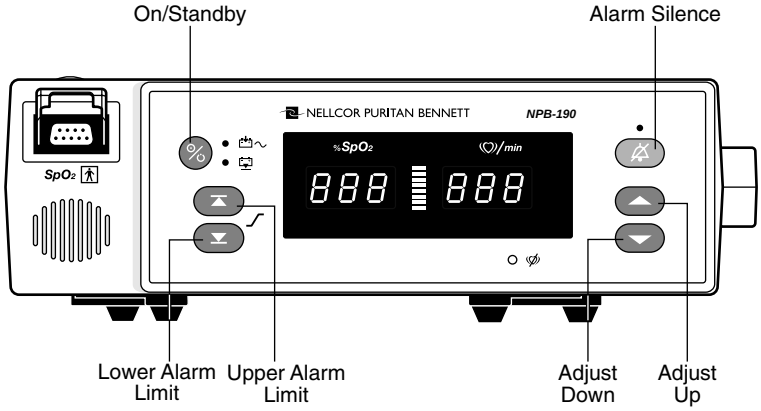
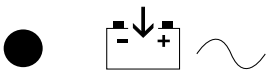


Figure 3-1: NPB-190 Controls

Note: Refer to Figure 3-1, NPB-190 Controls, when following the instructions listed below.

3.3.2.1 Power-On Self-Test

1. Connect the monitor to an AC power source. Verify that the AC Power/Battery Charging indicator is lit.



2. Do not connect any input cables to the monitor.

3. Observe the monitor front panel. With the monitor off, press the Power On/Standby button. Verify that the monitor performs the following sequence:

a. All indicators light for a few seconds as illustrated in Figure 3-2.

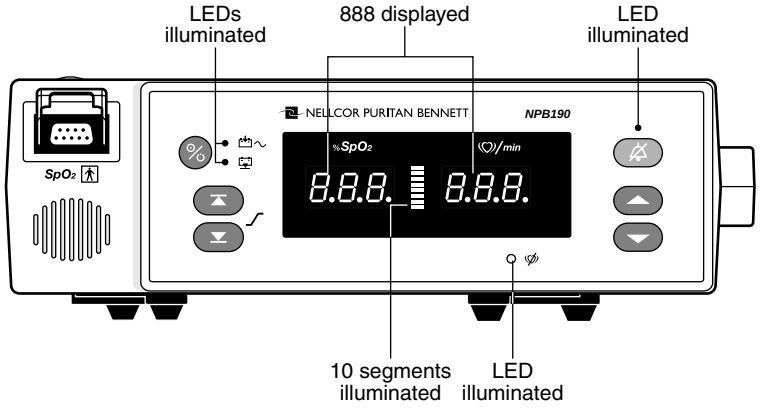


Figure 3-2: Self-Test Display

b. The software version is displayed and the AC Power/Battery Charging indicators remain on.

c. When a sensor is connected a zero is displayed in each window, a 1-second Power-On Self-Test (POST) beep sounds and the Pulse Search LED is illuminated.

   If no sensor is connected a 1 second POST beep sounds, 3 dashes are displayed in each window and the Pulse Search LED is off.

d. The NPB-190 begins normal operation if a sensor is connected. Without a sensor the monitor will be in the idle mode (3 dashes in each window).

3.3.2.2 Factory Power-On Defaults and Alarm Limit Ranges

Note: When observing or changing default limits, a 3-second timeout is in effect, that is, if no action is taken within 3 seconds, the monitor automatically returns to the normal mode.

1. Turn the monitor on by pressing the Power On/Standby button. Wait for POST to be completed. Press and release the Upper Alarm Limit button. Verify that the monitor emits a single beep and the %SpO2 display indicates a high alarm limit of "100" for about 3 seconds. Verify that three dashes are displayed at the top of the pulse rate display window.

Note: The location of the three dashes indicates the type of alarm limit that is being adjusted. Three dashes in the top of the display window indicate a high alarm limit and three dashes in the bottom of the display window indicate a low alarm limit.

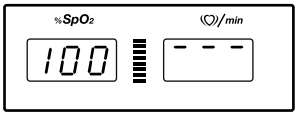


Figure 3-3: Adjusting High %SpO2 Alarm Limit

Normal monitoring is resumed after 3 seconds.

2. Press the Upper Alarm Limit button. Press and hold the Adjust Down button. Verify that the %SpO2 display reduces to a minimum of "85".

Note: A decimal point to the right of the value in either display indicates that the alarm limits are not power-on default values.

3. Press the Lower Alarm Limit button. Verify that the monitor emits a single beep and that the %SpO2 display indicates an alarm limit of "85" for 3 seconds. Verify that three dashes are displayed at the bottom of the pulse rate display window.

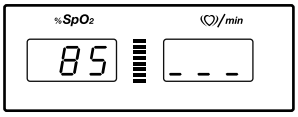


Figure 3-4: Adjusting Low %SpO2 Alarm Limit

4. Press the Lower Alarm Limit button. Press and hold the Adjust Down button and verify that the %SpO2 display reduces to a minimum of "20". Press and hold the Adjust Up button and verify that the %SpO2 display cannot be raised past the upper alarm limit setting of "85".

5. Press the Upper Alarm Limit button two times rapidly (twice within 3 seconds). Verify that the monitor emits two beeps, the pulse rate display indicates an alarm limit of "170", and that the %SpO2 display window shows three dashes at the top for about 3 seconds.

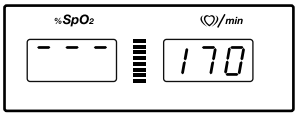


Figure 3-5: Adjusting High Heart Rate Alarm Limit

6. Press the Upper Alarm Limit button two times rapidly. Press and hold the Adjust Down button. Verify that the pulse rate display reduces to a minimum of "40".

7. Press the Lower Alarm Limit button two times rapidly. Verify that the pulse rate display indicates an alarm limit of "40" and that the %SpO2 display window shows three dashes at the bottom for 3 seconds.

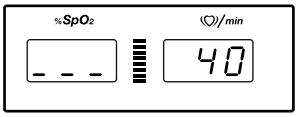


Figure 3-6: Adjusting Low Heart Rate Alarm Limit

8. Press the Lower Alarm Limit button two times rapidly. Press and hold the Adjust Down button. Verify that the pulse rate display reduces to a minimum of "30".

9. Press the Lower Alarm Limit button two times rapidly. Press and hold the Adjust Up button and verify that the pulse rate display cannot be adjusted above "40".

10. Press the Power On/Standby button to turn the unit off. Turn the unit back on.

11. Press and release the Upper Alarm Limit button. Verify that the %SpO_2 display indicates an alarm limit of "100".

12. Press and release the Lower Alarm Limit button. Verify that the %SpO_2 display indicates an alarm limit of "85".

13. Press the Upper Alarm Limit button two times rapidly. Verify that the pulse rate display indicates an alarm limit of "170".

14. Press the Lower Alarm Limit button two times rapidly. Verify that the pulse rate display indicates an alarm limit of "40".

15. Press the Power On/Standby button to turn the monitor off.

3.3.3 Hardware and Software Tests

Hardware and software testing include the following tests:

- Operation with a Pulse Oximeter Tester
- General Operation

3.3.3.1 Operation with a Pulse Oximeter Tester

Operation with an SRC-2 pulse oximeter tester includes the following tests:

- Alarms and Alarm Silence
- Alarm Volume Control
- Pulse Tone Volume Control
- Dynamic Operating Range
- Nurse Call

3.3.3.1.1 Alarms and Alarm Silence

1. Connect the SRC-2 pulse oximeter tester to the sensor input cable and connect the cable to the monitor. Set the SRC-2 as follows:

SWITCH	**POSITION**
RATE	38
LIGHT	HIGH
MODULATION	OFF
RCAL/MODE	RCAL 63/LOCAL

2. Press the Power On/Standby button to turn the monitor on. After the normal power-up sequence, verify that the pulse rate initially indicates zeroes.

   Note: The pulse bar may occasionally indicate a step change as the monitor is in the pulse search mode.

3. Set the modulation switch on the SRC-2 to HIGH.

4. Verify the following monitor reactions:

a. The pulse blip bar begins to track the artificial pulse signal from the SRC-2.

b. The pulse tone is heard.

c. Zeroes are displayed in the %SpO_2 and pulse rate displays.

d. After about 10 to 20 seconds, the monitor displays oxygen saturation and pulse rate as specified by the tester. Verify that the values are within the following tolerances:

Oxygen Saturation Range 79% to 83%
Pulse Rate Range 37 to 39 bpm

e. The audible alarm sounds and both the %SpO_2 and pulse rate displays flash. This is an indication that both parameters have violated the default alarm limits.

5. Press and hold the Alarm Silence button on the front of the monitor for less than 3 seconds. Verify that the pulse rate display indicates "SEC" and the %SpO_2 display indicates "60" while the Alarm Silence button is pressed. The alarm is silenced when the button is released.

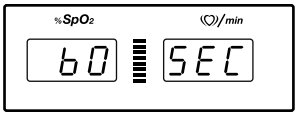


Figure 3-7: Alarm Silence Duration

6. Release the Alarm Silence button. Verify the following:

a. The alarm remains silenced.

b. The Alarm Silence indicator lights.

c. The %SpO_2 and pulse rate displays resume flashing.

d. The pulse tone is still audible.

e. The audible alarm returns after approximately 60 seconds.

7. While pressing the Alarm Silence button, press the Adjust Down button until the %SpO_2 display indicates "30". Press the Adjust Up button and verify that the displays indicate 60 SEC, 90 SEC, 120 SEC, and OFF. Release the button when the display indicates "OFF". Press the Alarm Silence button again and verify that the Alarm Silence indicator flashes.

8. Wait approximately 3 minutes. Verify that the alarm does not return. After 3 minutes ± 10 seconds, the alarm silence reminder beeps three times, and continues to do so at 3-minute intervals.

3.3.3.1.2 Alarm Volume Control

After completing the procedure in paragraph 3.3.3.1.1:

1. Press and hold the Alarm Silence button for more than 3 seconds. Verify the following:

   a. "OFF" is displayed for approximately 3 seconds.

   b. After 3 seconds, a steady tone is heard at the default alarm volume setting, the %SpO_2 display indicates "VOL", and the pulse rate display indicates the default setting of 5.

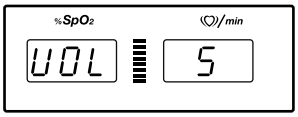


Figure 3-8: Alarm Volume Display

2. Press the Adjust Down button until an alarm volume setting of 1 is displayed. Verify that the volume of the alarm has decreased but is still audible.

3. Press the Adjust Up button to increase the alarm volume setting to a maximum value of 10. Verify that the volume increases. Press the Adjust Down button until a comfortable audio level is attained.

4. Release the Alarm Silence button. The tone stops.

3.3.3.1.3 Pulse Tone Volume Control

1. When a valid pulse has been acquired, press the Adjust Up button and verify that the beeping pulse tone sound level increases.

2. Press the Adjust Down button and verify that the beeping pulse tone decreases until it is no longer audible. Press the Adjust Up button to return the beep volume to a comfortable level.

3.3.3.1.4 Dynamic Operating Range

The following test sequence verifies proper monitor operation over a range of input signals:

1. Connect the SRC-2 to the NPB-190 and turn the NPB-190 on.

2. Place the SRC-2 in the RCAL 63/LOCAL mode.

3. Set the SRC-2 as indicated in Table 3-1. Verify that the NPB-190 readings are within the indicated tolerances. Allow the monitor several seconds to stabilize the readings.

Note: A (*) indicates values that produce an alarm. Press the Alarm Silence button to silence the alarm.

Table 3-1: Dynamic Operating Range

SRC-2 Settings			NPB-190 Indications	
RATE	**LIGHT**	**MODULATION**	**SpO2**	**Pulse Rate**
38	HIGH2	LOW	79 - 83*	37 - 39*
112	HIGH1	HIGH	79 - 83*	110 - 114
201	LOW	LOW	79 - 83*	198 - 204*
201	LOW	HIGH	79 - 83*	198 - 204*

3.3.3.1.5 Nurse Call

Note: The Nurse Call tests must be performed with the instrument operating on AC power.

1. Connect the negative lead of a voltmeter to pin 10 and positive to pin 11 of the serial port on the back of the instrument (Figure A-1 in appendix). Ensure that the audible alarm is not silenced or turned off.

2. Set the SRC-2 to create an alarm condition. Verify an output voltage at pins 10 and 11 between +5 to +12 VDC.

3. Press the Alarm Silence button. With no active audible alarm, the output voltage at pins 10 and 11 must be between -5 to -12 VDC.

4. Turn the instrument off. Disconnect the voltmeter and the SRC-2.

3.3.3.1.6 Operation on Battery Power

1. Turn the instrument on using AC Power.

2. Disconnect the instrument from AC and verify that the AC Power Indicator turns off.

3. Verify that the instrument continues monitoring normally and that the Low Battery Indicator is not lit.

Note: If the Low Batter Indicator is illuminated, perform the procedure outlined in step 3.3.1.

4. Connect the instrument to AC and verify that the AC Power Indicator turns on and that the instrument is monitoring normally.

3.3.3.2 General Operation

The following tests are an overall performance check of the system:

- LED Excitation Test
- Monitor Operation with a Live Subject

3.3.3.2.1 LED Excitation Test

This procedure uses normal system components to test circuit operation. A *Nellcor Oxisensor II*® oxygen transducer, model D-25, is used to examine LED intensity control. The red LED is used to verify intensity modulation caused by the LED intensity control circuit.

1. Connect the monitor to an AC power source.
2. Connect an EC-4 or EC-8 sensor input cable to the monitor.
3. Connect a D-25 sensor to the sensor input cable.
4. Press the Power On/Standby button to turn the monitor on.
5. Leave the sensor open with the LEDs and photodetector visible.
6. After the monitor completes its normal power-up sequence, verify that the sensor LED is brightly lit.
7. Slowly move the sensor LED in proximity to the photodetector element of the sensor. Verify, as the LED approaches the photodetector, that the LED intensity decreases.
8. Open the sensor and notice that the LED intensity increases.
9. Repeat step 7 and the intensity will again decrease. This variation is an indication that the microprocessor is in proper control of LED intensity.
10. Turn the NPB-190 off.

3.3.3.2.2 Monitor Operation with a Live Subject

Pulse oximetry involves connecting the monitor to a live subject for a qualitative test.

1. Ensure that the monitor is connected to an AC power source.
2. Connect an EC-4 or EC-8 sensor input cable to the monitor.
3. Connect a *Nellcor Durasensor*® oxygen transducer, model DS-100A, to the sensor input cable.
4. Clip the DS-100A to an adult subject as recommended in the sensor directions for use.
5. Press the Power On/Standby button to turn the monitor on and verify that the monitor is operating.
6. The monitor should stabilize on the subject's physiological signal in about 15 to 30 seconds. Verify that the saturation and heart rates are reasonable for the subject.

3.4 SAFETY TESTS

NPB-190 safety tests meet the standards of, and are performed in accordance with, IEC 601-1 (EN 60601-1, Second Edition, 1988; Amendment 1, 1991-11, Amendment 2, 1995-03) and UL 2601-1 (August 18, 1994), for instruments classified as Class 1 and TYPE BF and AAMI Standard ES1 (ANSI/AAMI ES1 1993).

- Ground Integrity
- Electrical Leakage

3.4.1 Ground Integrity

This test checks the integrity of the power cord ground wire from the AC plug to the instrument chassis ground. The current used for this test is ≤ 6V RMS 50 or 60 Hz and 25 A.

1. Connect the monitor AC mains plug to the analyzer as recommended by the analyzer operating instructions.

2. Connect the analyzer resistance input lead to the equipotential terminal (grounding lug) on the rear panel of the instrument. Verify that the analyzer indicates 100 milliohms or less.

3.4.2 Electrical Leakage

The following tests verify the electrical leakage of the monitor:

- Earth Leakage Current
- Enclosure Leakage Current
- Patient Leakage Current
- Patient Source Current (Mains on Applied Part)

Note: For the following tests, ensure that the AC switch on the rear of the instrument is configured for the AC voltage being supplied.

3.4.2.1 Earth Leakage Current

This test is in compliance with IEC 601-1 (earth leakage current) and AAMI Standard ES1 (earth risk current). The applied voltage for AAMI ES1 is 120 VAC 60 Hz, for IEC 601-1 the voltage is 264 VAC 50 to 60 Hz. All measurements shall be made with the power switch in both the "On" and "Off" positions.

1. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions.

2. The equipotential terminal is not connected to ground.

Table 3-2: Earth Leakage Current Limits

AC POLARITY	LINE CORD	NEUTRAL CORD	LEAKAGE CURRENT
Normal	Closed	Closed	500 µA
Reversed	Closed	Closed	500 µA
Normal	Open	Closed	1000 µA
Normal	Closed	Open	1000 µA

3.4.2.2 Enclosure Leakage Current

This test is in compliance with IEC 601-1 (enclosure leakage current) and AAMI Standard ES1 (enclosure risk current). This test is for ungrounded enclosure current, measured between enclosure parts and earth. The applied voltage for

AAMI/ANSI is
120 VAC 60 Hz, and for IEC 601-1 the applied voltage is 264 VAC 50 to 60 Hz.

1. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions.

2. Place a 200 cm^2 foil in contact with the instrument case making sure the foil is not in contact with any metal parts of the enclosure that may be grounded. Measure the leakage current between the foil and earth.

The analyzer leakage indication must not exceed values listed in the table below:

Table 3-3: Enclosure Leakage Current Limits

AC LINE CORD	NEUTRAL LINE CORD	POWER LINE GROUND CABLE	IEC 601-1	AAMI/ANSI ES1 STANDARD
Closed	Closed	Closed	100 µA	100 µA
Closed	Closed	Open	500 µA	300 µA
Closed	Open	Closed	500 µA	300 µA
Open	Closed	Closed	500 µA	100 µA
Open	Open	Closed	500 µA	300 µA
Open	Closed	Open	500 µA	300 µA

3.4.2.3 Patient Applied Risk Current

This test is in compliance with AAMI Standard ES1 (patient applied risk current), and IEC 601-1 (patient auxiliary current). The leakage current is measured between any individual patient connection and power (earth) ground. The applied voltage for AAMI/ANSI is 120 VAC 60 Hz, and for IEC 601-1 the applied voltage is 264 VAC 50 to 60 Hz.

1. Configure the electrical safety analyzer as follows:

   Function: Patient Leakage
   Range: µA

2. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions for Patient Leakage Current.

3. Connect the electrical safety analyzer patient leakage input lead to all pins of the monitor's patient cable at the end of the cable.

4. The equipotential terminal is not connected to ground.

5. All functional earth terminals are not connected to ground.

6. Measure the leakage current between the patient connector and earth.

Table 3-4: Patient Leakage Current Limits

AC LINE POLARITY	NEUTRAL LINE	POWER LINE GROUND CABLE	IEC 601-1	AAMI/ANSI ES1 STANDARD
Normal	Closed	Closed	100 µA	10 µA
Normal	Open	Closed	500 µA	50 µA
Normal	Closed	Open	500 µA	50 µA
Reverse	Closed	Closed	100 µA	10 µA
Reverse	Open	Closed	500 µA	50 µA
Reverse	Closed	Open	500 µA	50 µA

3.4.2.4 Patient Isolation Risk Current - (Mains Voltage on the Applied Part)

This test is in compliance with AAMI Standard ES1 (patient isolation risk current [sink current]), and IEC 601-1 (patient leakage current). Patient Leakage Current is the measured value in a patient connection if mains voltage is connected to that patient connection. The applied voltage for AAMI/ANSI is 120 VAC 60 Hz, and for IEC 601-1 the applied voltage is 264 VAC 50 to 60 Hz.

Warning: AC mains voltage will be present on the patient applied part terminals during this test. Exercise caution to avoid electrical shock hazard.

1. Configure the electrical safety analyzer as follows:

   Function: Patient Leakage (Mains On Applied Part)
   Range: µA

2. Connect the monitor AC plug to the electrical safety analyzer as recommended by the operating instructions for patient sink (leakage) current.

3. Connect the electrical safety analyzer patient leakage input lead to all connectors in the patient cable at the patient end of the cable.

4. The equipotential terminal is not connected to ground.

5. All functional earth terminals are not connected to ground.

6. The analyzer leakage current must not exceed the values shown in the table below.

Table 3-5: Patient Leakage Current Test Configurations - Mains Voltage on the Applied Part

AC LINE POLARITY	NEUTRAL LINE	POWER LINE GROUND CABLE	IEC 601-1	AAMI/ANSI ES1 STANDARD
Normal	Closed	Closed	5 mA	50 µA
Reverse	Closed	Closed	5 mA	50 µA

SECTION 4: AUDIBLE ALARM SETTINGS & SERVICE MENU

4.1 Introduction
4.2 Audible Alarm Settings
4.3 Service Menu

4.1 INTRODUCTION

This section discusses use of the service menu to reconfigure power-on default values, and how to control the behavior of the audible alarm.

4.2 AUDIBLE ALARM SETTINGS

The following paragraphs describe how to change the behavior of the audible alarm. Operators can select the volume of the alarm and the duration of alarm silence. Controls for the NPB-190 are shown in Figure 4-1.

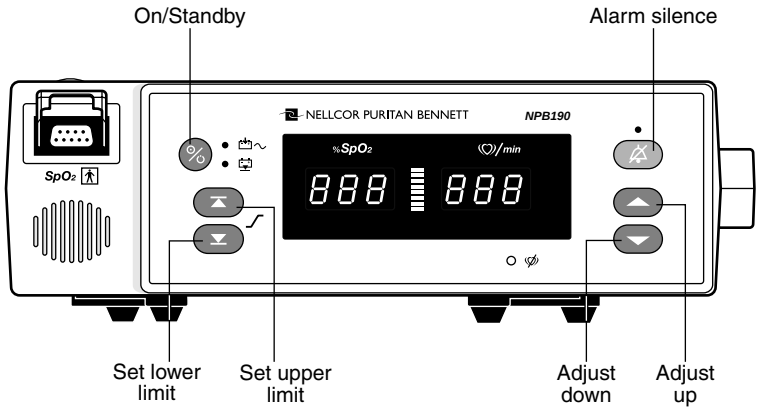


Figure 4-1: NPB-190 Controls

4.2.1 Alarm Silence State

Press the Alarm Silence button to silence the alarm. Press the button a second time to turn the alarm back on.

4.2.2 Alarm Silence Duration

1. Press and hold the Alarm Silence button for less than 3 seconds.

2. Before 3 seconds have passed the Adjust Up or Adjust Down button can be used to change the duration of the alarm silence. The alarm's duration can be 30, 60, 90, 120 seconds, or the alarm can be turned off.

4.2.3 Alarm Volume

1. Press and hold the Alarm Silence button for more than 3 seconds.

2. After 3 seconds, while still pressing the Alarm Silence button, the Adjust Up or Adjust Down button can be used to select alarm volumes from 1 to 10. Select a level that is suitable for the monitor's location.

4.3 SERVICE MENU

The menu items listed below should be accessed only by a qualified service technician. Power-on default values can be changed for the behavior of the audible alarm, alarm limits, and for the serial port.

4.3.1 Accessing Menu Items

1. Menu items can be accessed at any time by pressing the Upper and Lower Alarm Limit buttons simultaneously for at least 3 seconds. The service menu has been accessed when a 1 appears in the pulse rate display.

2. Pressing the Adjust Up or Adjust Down button selects the menu item number. Menu numbers 5 and 6, have items within them that can be selected by first pressing the Upper Alarm Limit button, and then pressing the Adjust Up or Adjust Down key.

Note: Service menu items greater than 2 cannot be accessed if a sensor is connected to the monitor.

3. Once adjustments have been made within a menu item the, Upper Alarm Limit button can be used to initiate the current selection. Three tones will sound to indicate that the change has been accepted, and the monitor will return to normal monitoring.

4. The service menu can be exited without making changes by pressing the Lower Alarm Limit button. If a period of 10 seconds passes with no button presses, the instrument will exit the service menu, go to normal monitoring, and no changes will have been made.

4.3.2 Menu Item 1 (Save Current Values as Power-On Default)

1. If menu item 1 is selected, the current values for alarm limits, alarm volume, pulse beep volume, audible alarm silence duration, alarm silence behavior, and baud rate will be saved as the power-on default settings. Some values are not allowed to be saved as power on default values, they are; an Alarm Silence Duration of Off, and low %SpO_2 alarm limits less than 80%. If an invalid tone is heard instead of the triple beep the current settings were not changed.

Note: Current values will not be stored in memory as defaults, if power is interrupted before exiting this menu option.

Note: When the operator changes an alarm limit to a value other than a power on default value, a decimal point will appear to the right of the parameter whose alarm limit was changed.

4.3.3 Menu Item 2 (Return to Default Settings)

Menu item 2 resets the monitor to factory default settings as shown in table 4-1.

Table 4-1: Factory Default Settings

Parameter	Default Value
SpO2 High	100%
SpO2 Low	85%
Pulse rate High	170 bpm
Pulse rate Low	40 bpm
Pulse beep volume	Level 4
Alarm Volume	Level 5
Alarm Silence Duration	60 seconds
Alarm Silence Behavior	0 (Off with reminder)
Baud Rate	9600

Note: Menu items greater than 2 cannot be accessed when a valid sensor is plugged into the unit.

Note: To reach menu item 5 two invalid tones will be heard when passing through menu items 3 and 4.

4.3.4 Menu Item 3 (Not Displayed)

4.3.5 Menu Item 4 (Not Displayed)

4.3.6 Menu Item 5 (Alarm Silence Behavior)

1. This menu item is used to change alarm silence behavior. Three options; 0, 1, or 2 can be accessed by first pressing the Upper Alarm Limit button, then using the Adjust Up or Down button to scroll to the desired number.

2. Option “0” will allow the operator to select Alarm Silence, but there will be a reminder tone every 3 minutes.

3. Option “1” allows the operator to select Alarm Silence and there will be **no** reminder tone.

4. Option “2” will not allow the operator to select Alarm Silence.

5. When the desired option is indicated in the display, press the Upper Alarm Limit button to save the current selection. Three tones will sound to indicate that the change has been accepted

Note: The low battery audible alarm cannot be disabled.

4.3.7 Menu Item 6 (Baud Rate)

1. Baud rates of 2400, 9600, and 19200 can be selected by first pressing the Upper Alarm Limit button, then using the Adjust Up or Adjust Down button to select the desired baud rate. The baud rates will be displayed in the %SpO_2 window as 24, 96, or 192.

2. When the desired option is indicated in the display, press the Upper Alarm Limit button to save the current selection. Three tones will sound to indicate that the change has been accepted.

4.3.8 Menu Item 7

Do not use. For use by Mallinckrodt Customer Service Engineer.

4.3.9 Menu Item 8

Do not use. For use by Mallinckrodt Customer Service Engineer.

4.3.10 Menu Item 9

Do not use. For use by Mallinckrodt Customer Service Engineer.

SECTION 5: TROUBLESHOOTING

5.1 Introduction
5.2 How to Use this Section
5.3 Who Should Perform Repairs
5.4 Replacement Level Supported
5.5 Obtaining Replacement Parts
5.6 Troubleshooting Guide
5.7 Error Codes

5.1 INTRODUCTION

This section explains how to troubleshoot the NPB-190 if problems arise. Tables are supplied that list possible monitor difficulties, along with probable causes, and recommended actions to correct the difficulty.

5.2 HOW TO USE THIS SECTION

Use this section in conjunction with Section 3, *Performance Verification*, and Section 7, *Spare Parts*. To remove and replace a part you suspect is defective, follow the instructions in Section 6, *Disassembly Guide*. The circuit analysis section in the Technical Supplement offers information on how the monitor functions.

5.3 WHO SHOULD PERFORM REPAIRS

Only qualified service personnel should open the monitor housing, remove and replace components, or make adjustments. If your medical facility does not have qualified service personnel, contact Mallinckrodt Technical Services or your local Mallinckrodt representative.

5.4 REPLACEMENT LEVEL SUPPORTED

The replacement level supported for this product is to the printed circuit board (PCB) and major subassembly level. Once you isolate a suspected PCB, follow the procedures in Section 6, *Disassembly Guide,* to replace the PCB with a known good PCB. Check to see if the symptom disappears and that the monitor passes all performance tests. If the symptom persists, swap back the replacement PCB with the suspected malfunctioning PCB (the original PCB that was installed when you started troubleshooting) and continue troubleshooting as directed in this section.

5.5 OBTAINING REPLACEMENT PARTS

Mallinckrodt Technical Services provides technical assistance information and replacement parts. To obtain replacement parts, contact Mallinckrodt or your local Mallinckrodt representative. Refer to parts by the part names and part numbers listed in Section 7, *Spare Parts*.

5.6 TROUBLESHOOTING GUIDE

Problems with the NPB-190 are separated into the categories indicated in Table 5-1. Refer to the paragraph indicated for further troubleshooting instructions.

Note: Taking the recommended actions discussed in this section will correct the majority of problems you will encounter. However, problems not covered here can be resolved by calling Mallinckrodt Technical Services or your local representative.

Table 5-1: Problem Categories

Problem Area	Refer to Paragraph
1. Power • No power-up on AC and/or DC • Fails power-on self-test • Powers down without apparent cause	5.6.1
2. Buttons • Monitor does not respond properly to buttons	5.6.2
3. Display/Alarms • Displays do not respond properly • Alarms or other tones do not sound properly or are generated without apparent cause	5.6.3
4. Operational Performance • Displays appear to be operational, but monitor shows no readings • Suspect readings	5.6.4
5. Serial Port • NPB-190 and PC not communicating properly • Nurse Call not functioning properly	5.6.5

All of the categories in Table 5-1 are discussed in the following paragraphs.

5.6.1 Power

Power problems are related to AC and/or DC. Table 5-2 lists recommended actions to power problems.

Table 5-2: Power Problems

Condition	Recommended Action
1. BATTERY LOW indicator lights steadily while NPB-190 is connected to AC and battery is fully charged.	1. Ensure that the NPB-190 is plugged into an operational AC outlet and the AC indicator is on. 2. Check the fuses. The Power Entry Module contains the fuses as indicated in paragraph 6.3 and Figure 6-3 of the *Disassembly Guide* section. Replace if necessary. 3. Open the monitor as described in section 6. Verify power supply's output to the battery while on AC. Disconnect the battery leads from the battery and connect a DVM to them. The voltage measured should be 6.8 VDC $\pm$ 0.15 and the current should be 400 mA $\pm$ 80 mA. Replace power supply if above values are not met. 4. Check the cable connection from the bottom enclosure to the UIF PCB, as instructed in paragraph 6.5 of the *Disassembly Guide* section. If the connection is good, replace the UIF PCB.
2. The NPB-190 does not operate when disconnected from AC power.	1. The battery may be discharged. To recharge the battery, refer to paragraph 3.3.1, Battery Charge. The monitor may be used with a less than fully charged battery but with a corresponding decrease in operating time from that charge. 2. If the battery fails to hold a charge, replace the battery as indicated in Section 6, *Disassembly Guide*.
3. BATTERY LOW indicator on during DC operation and an alarm is sounding.	There are 15 minutes or less of usable charge left on the NPB-190 battery before the instrument shuts off. At this point, if possible, cease use of the NPB-190 on battery power, connect it to an AC source, and allow it to recharge. The full recharge takes 14 hours. The NPB-190 may continue to be used while it is recharging.
4. Battery does not charge.	1. Replace battery if more than 2 years old. 2. Open the monitor as described in Section 6. Verify power supply's output to the battery while on AC. Disconnect the battery leads from the battery and connect a DVM to them. The voltage measured should be 6.8 VDC ± 0.15 and the current should be 400 mA ± 80 mA. Replace power supply if above values are not met.

5.6.2 Buttons

Table 5-3 lists symptoms of problems relating to nonresponsive buttons and recommended actions. If the action requires replacement of a PCB, refer to Section 6, *Disassembly Guide*.

Table 5-3: Button Problems

Condition	Recommended Action
1. The NPB-190 responds to some, but not all buttons.	1. Replace Top Housing assembly. 2. If the buttons still do not work, replace the UIF PCB.
2. The NPB-190 turns on but does not respond to any of the buttons.	1. Check the connection between the membrane panel and J5 of the UIF PCB. 2. Replace Top Housing assembly. 3. If the buttons still do not work, replace the UIF PCB.

5.6.3 Display/Alarms

Table 5-4 lists symptoms of problems relating to nonfunctioning displays, audible tones or alarms, and recommended actions. If the action requires replacement of a PCB or module, refer to Section 6, *Disassembly Guide*.

Table 5-4: Display/Alarms Problems

Condition	Recommended Action
1. Display values are missing or erratic.	1. Try another sensor or relocate the sensor to a different site. 2. If the sensor is connected, replace the sensor connector assembly. 3. If the condition persists, replace the sensor extension cable. 4. If the condition still persists, replace the UIF PCB.
2. All display segments do not light during POST.	1. Check the connection between the UIF PCB and the Display PCB. 2. If the condition does not change, replace the Display PCB. 3. If the condition still persists, replace the UIF PCB.
3. All Front Panel LED indicators do not light during POST.	1. Check the connection between the membrane panel and J5 of the UIF PCB. 2. Replace Top Housing assembly.
4. Alarm sounds for no apparent reason.	1. Moisture or spilled liquids can cause an alarm to sound. Allow the monitor to dry thoroughly before using. 2. If the condition persists, replace the UIF PCB.

Table 5-4: Display/Alarms Problems (cont. from page 5-4)

Condition	Recommended Action
5. Alarm does not sound.	1. Check speaker connection to UIF PCB. 2. Replace the speaker as described in Section 6, *Disassembly Guide*. 3. If the condition persists, replace the UIF PCB.

Table 5-5 lists symptoms of problems relating to operational performance (no error codes displayed) and recommended actions. If the action requires replacement of a PCB or module, refer to Section 6, *Disassembly Guide*.

Table 5-5: Operational Performance Problems

Condition	Recommended Action
1. The Pulse Amplitude indicator seems to indicate a pulse, but the digital displays show zeroes.	1. The sensor may be damaged; replace it. 2. If the condition still persists, replace the UIF PCB.
2. SpO2 or pulse rate values change rapidly; Pulse Amplitude indicator is erratic.	1. The sensor may be damp or may have been reused too many times. Replace it. 2. An electrosurgical unit (ESU) may be interfering with performance: ñ Move the NPB-190 and its cables and sensors as far from the ESU as possible. ñ Plug the NPB-190 and the ESU into different AC circuits. ñ Move the ESU ground pad as close to the surgical site as possible and as far away from the sensor as possible. 3. Verify performance with the procedures detailed in Section 3. 4. If the condition still persists, replace the UIF PCB.

5.6.5 Serial Port

Table 5-6 lists symptoms of problems relating to the serial port and recommended actions. If the action requires replacement of the PCB, refer to Section 6, *Disassembly Guide*.

Table 5-6: Serial Port Problems

Condition	Recommended Action
1. No printout is being received.	1. The unit is running on battery power. Connect to an AC source. If the AC indicator is not on see section 5.6.1. 2. The monitor's baud rate does not match the printer. Change the baud rate of the monitor following instructions in section 4.3.7. 3. Check connections between serial port and printer (see section A3). 4. If the condition still persists, replace the UIF PCB.
2. The Nurse Call function is not working.	1. The unit is running on battery power. Connect to an AC source. If the AC indicator is not on see section 5.6.1. 2. Verify that connections are made between pins 5 or 10 (GND) and 11 (Nurse Call) of the serial port. 3. Verify that output voltage between ground pin 5 or 10 and pin 11 is -5 to -12 VDC (no alarm) and +5 to +12 VDC (during alarm). 4. If the condition still persists, replace the UIF PCB.

5.7 ERROR CODES

An error code will be displayed when the NPB-190 detects a non-correctable failure. When this occurs, the unit will stop monitoring, sound a low priority alarm that cannot be silenced, clear patient data from the display, and display an error code. Error codes will be displayed with EEE in the Saturation display and the number of the code in the Pulse Rate display, i.e., EEE 1. Table 5-7 provides a complete list of error codes and possible solutions.

Table 5-7: Error Codes

Code	Meaning	Possible Solutions
1	POST failure	Replace UIF PCB
4	Battery dead	1. Check the voltage selector switch. 2. Charge battery for 14 hours 3. Leads of battery reversed; see paragraph 6.5 4. Replace battery
5	Too many microprocessor resets within a period of time	1. Replace UIF PCB 2. Replace Power Supply
6	Boot CRC error	Replace UIF PCB
7	Error on UIF PCB	1. Cycle power to clear error. 2. Check voltage selector switch for proper setting. 3. Replace UIF PCB
11	Flash ROM corruption	Replace UIF PCB
76	Error accessing EEPROM	Replace UIF PCB
80	Institutional default values lost and reset to factory default values	Replace UIF PCB
84	Internal communications error	Replace UIF PCB

SECTION 6: DISASSEMBLY GUIDE

6.1 Introduction
6.2 Prior to Disassembly
6.3 Fuse Replacement
6.4 Monitor Disassembly
6.5 Monitor Reassembly
6.6 Battery Replacement
6.7 Power Entry Module (PEM) Removal/Installation
6.8 Power Supply Removal/Installation
6.9 Display PCB Removal/Installation
6.10 UIF PCB Removal/Installation
6.11 Alarm Speaker Removal/Installation

6.1 INTRODUCTION

The NPB-190 can be disassembled down to all major component parts, including:

- PCBs
- Battery
- Top and Bottom Housing
- Speaker
- Power Entry Module (PEM)

The following tools are required:

- Phillips-head screwdriver #1
- 10 mm open-end wrench
- Needle-nose pliers
- Torque wrench, 10 inch-pounds (1.13 newton-meters)
- Wire Cutters

WARNING: Before attempting to open or disassemble the NPB-190, disconnect the power cord from the NPB-190.

Caution: Observe ESD (electrostatic discharge) precautions when working within the unit.

Note: Some spare parts have a business reply card attached. When you receive these spare parts, please fill out and return the card.

6.2 PRIOR TO DISASSEMBLY

1. Turn the NPB-190 off by pressing the Power On/Standby button.

2. Disconnect the monitor from the AC power source.

6.3 FUSE REPLACEMENT

1. Complete the procedure in paragraph 6.2.

2. Disconnect the power cord from the back of the monitor.

3. Remove the fuse drawer from the Power Entry Module by pressing down on the tab in the center and pulling the drawer out as shown in Figure 6-1.

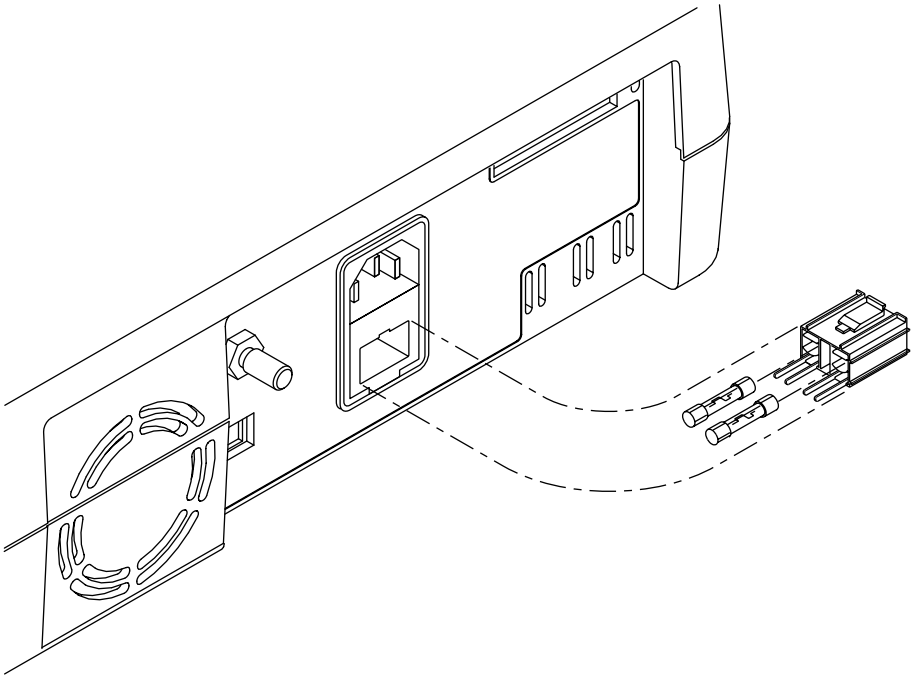


Figure 6-1: Fuse Removal

4. Put new 0.5 amp fuses in the drawer and reinsert the drawer in the power module.

6.4 MONITOR DISASSEMBLY

Caution: Observe ESD (electrostatic discharge) precautions when disassembling and reassembling the NPB-190 and when handling any of the components of the NPB-190.

1. Set the NPB-190 upside down, as shown in Figure 6-2.

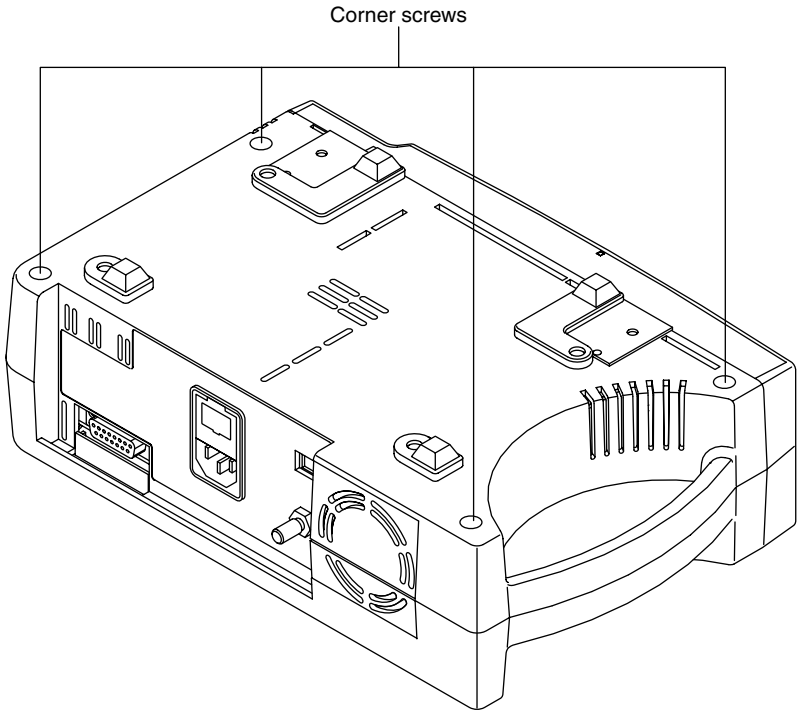


Figure 6-2: NPB-190 Corner Screws

2. Remove the four corner screws.

3. Turn the unit upright. Separate the top case from the bottom case of the monitor being careful not to stress the wire harnesses between the cases. Place the two halves of the monitor on the table as shown in Figure 6-3.

4. Disconnect the Power Supply from J6 on the UIF PCB.

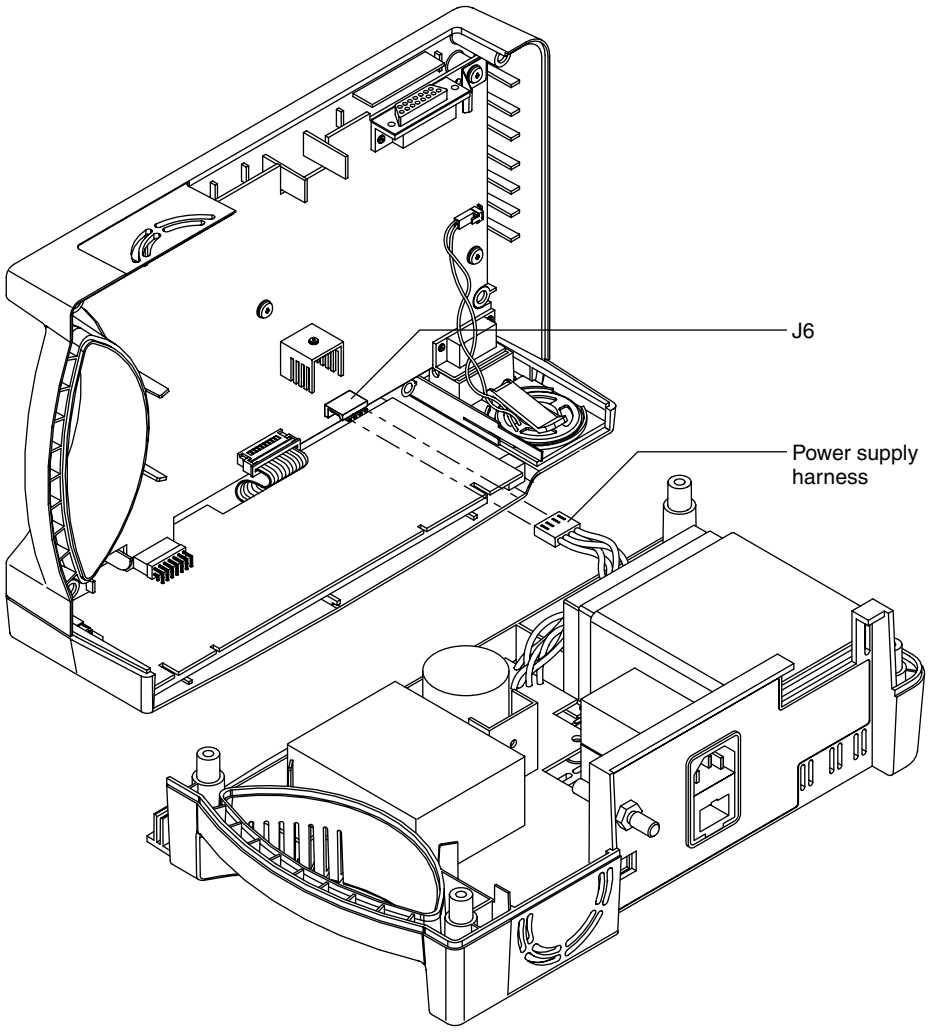


Figure 6-3: Separating Case Halves

6.5 MONITOR REASSEMBLY

1. Place the two halves of the monitor on the table as shown in Figure 6-3 and connect the Power Supply to J6 on the UIF PCB.

2. Place the top case over the bottom case and align the four outside screw posts and close the monitor.

Caution: When reassembling the NPB-190, hand tighten the screws that hold the cases together to a maximum of 10 inch-pounds. Over-tightening could strip out the screw holes in the top case, rendering them unusable.

3. Install the four corner screws.

6.6 BATTERY REPLACEMENT

Removal

1. Follow procedure in paragraphs 6.2 and 6.4.
2. Remove the two screws from the battery bracket shown in Figure 6-4 and lift the battery out of the bottom case.
3. Use needle-nose pliers to disconnect the leads from the battery.

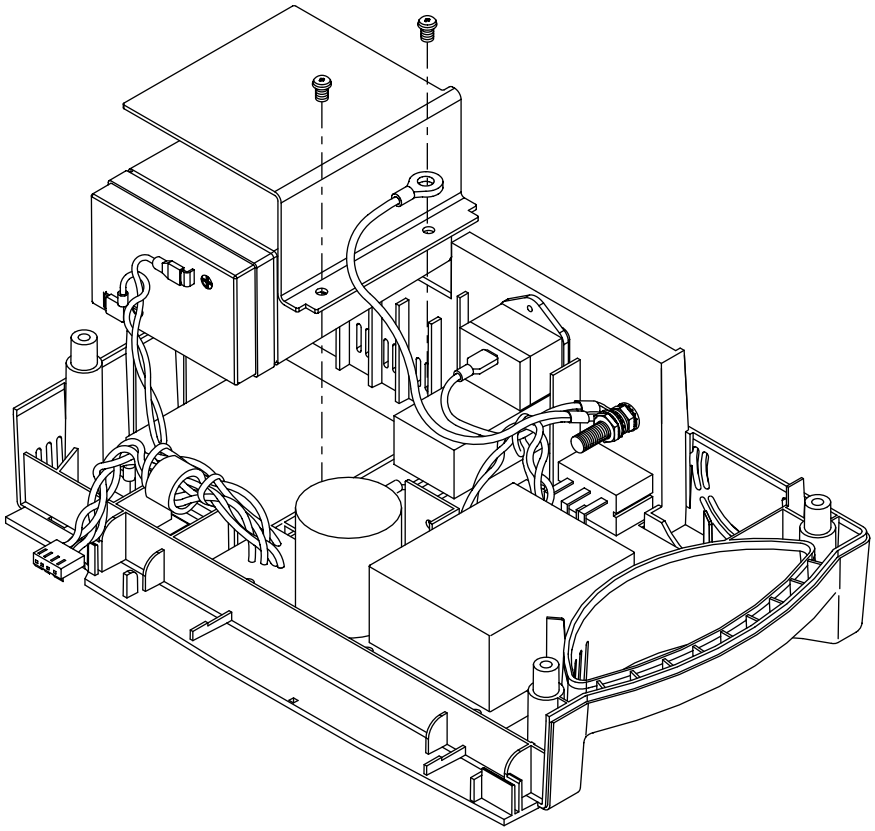


Figure 6-4: Battery Removal

4. The lead-acid battery is recyclable. Do not dispose of the battery by placing it in the regular trash. Dispose of properly according to state, local or other applicable regulations, or contact Mallinckrodt Technical Services to return for disposal.

Installation

5. Connect the leads to the battery. The red wire connects to the positive terminal and the black wire goes to the negative.
6. Insert the new battery into the bottom case with the negative terminal towards the bottom of the monitor. Install the bracket and grounding lead with the two screws.
7. Complete the procedure in paragraph 6.5.

8. Turn the monitor on and verify proper operation.

6.7 POWER ENTRY MODULE (PEM) REMOVAL/INSTALLATION

Removal

1. Complete the procedure in paragraphs 6.2 and 6.4.
2. While pushing the top of the PEM in from the outside of the case, gently push the case to the outside and lift up on the PEM.
3. Use needle-nose pliers to disconnect the leads from the PEM (see Figure 6-5).

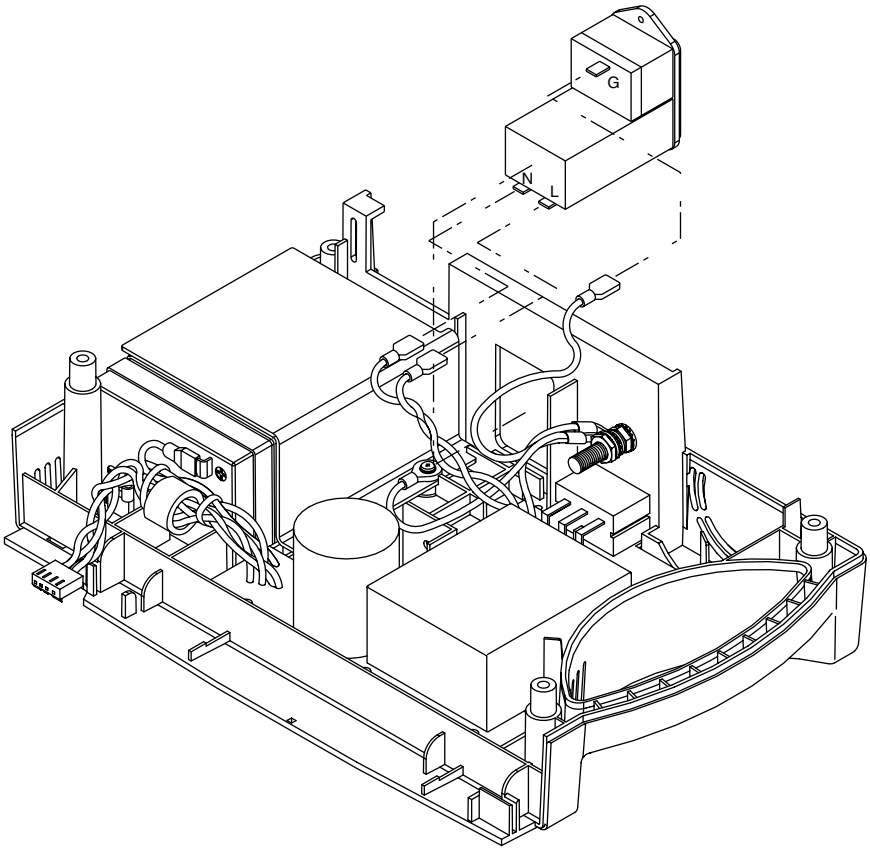


Figure 6-5: Power Entry Module

Installation

4. Reconnect the three leads. The blue “N” wire, from the power supply goes to the terminal labeled “N” on the PEM. The brown “L” wire, from the power supply connects to the terminal labeled “L” on the PEM. The center terminal at the top of the PEM is for the ground wire (Figure 6-6).
5. Install the PEM in the bottom case with the fuse drawer facing down. A tab in the bottom case holds the PEM in place. Insert the bottom wing of the PEM between the tab and the internal edge of the side wall of the bottom case. Push the PEM down and towards the outside of the monitor until it clicks into place.

6. Position the ground line from the PEM so that it does not come into contact with components on the Power Supply PCB.

7. Complete procedure in paragraph 6.5.

6.8 POWER SUPPLY REMOVAL/INSTALLATION

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.

2. Disconnect the leads from the battery.

3. Follow the procedure in paragraph 6.7, steps 2 and 3.

4. Use a 10mm wrench to disconnect the Power Supply ground lead from the equipotential lug (Figure 6-6).

5. Remove the seven screws shown in Figure 6-7.

6. Lift the Power Supply out of the bottom case.

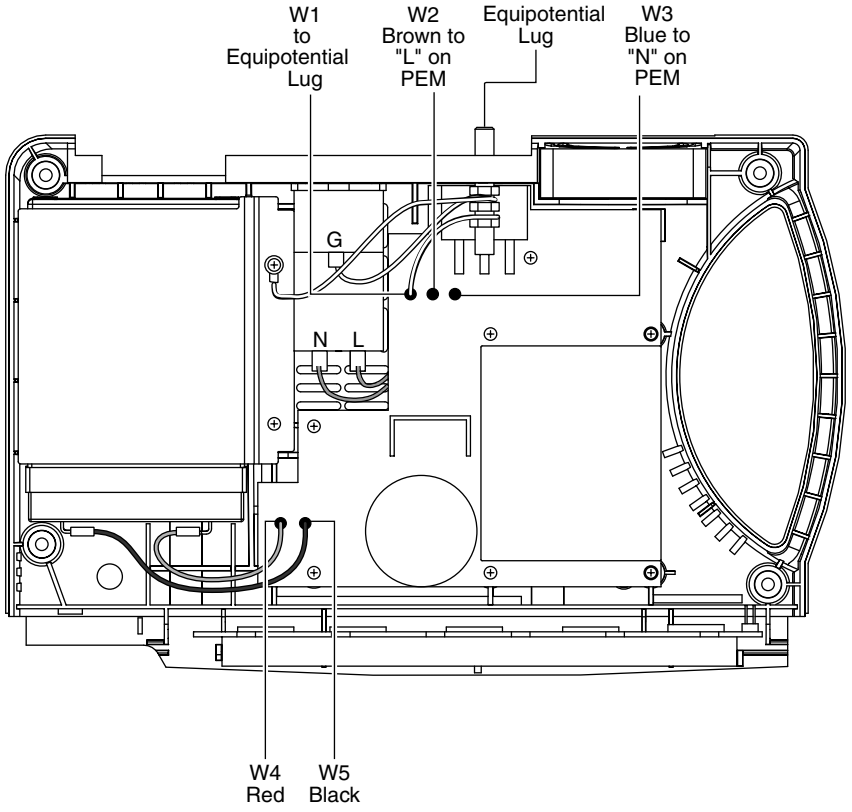


Figure 6-6: Power Supply Leads Connections

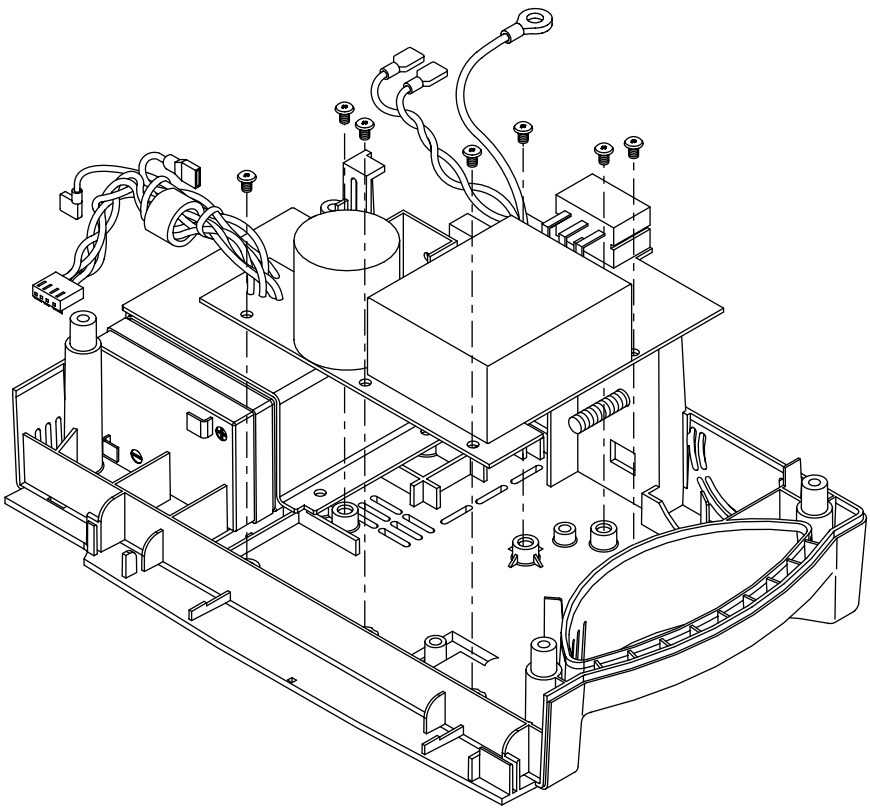


Figure 6-7: Power Supply

Installation

7. Reconnect the AC leads. The wire from the Power Supply labeled "N" goes to the terminal labeled "N" on the PEM. The wire from the power supply labeled "L" connects to the terminal labeled "L" on the PEM.

8. Place the Power Supply in the bottom case.

Caution: When installing the Power Supply, tighten the seven screws to a maximum of 10 inch-pounds. Overtightening could strip out the inserts in the bottom case, rendering them unusable.

9. Install the seven screws in the Power Supply and tighten.

10. Use a 10mm wrench to connect the power supply ground lead to the equipotential lug. Tighten to 12 inch pounds.

11. Follow the procedure in paragraph 6.7, step 5.

12. Connect the ground wire to the PEM and position it so that it does not come into contact with components on the Power Supply PCB.

13. Complete the procedure in paragraph 6-5.

6.9 DISPLAY PCB REMOVAL/INSTALLATION

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.
2. Lift the Display PCB up to remove it from the top case (Figure 6-8).

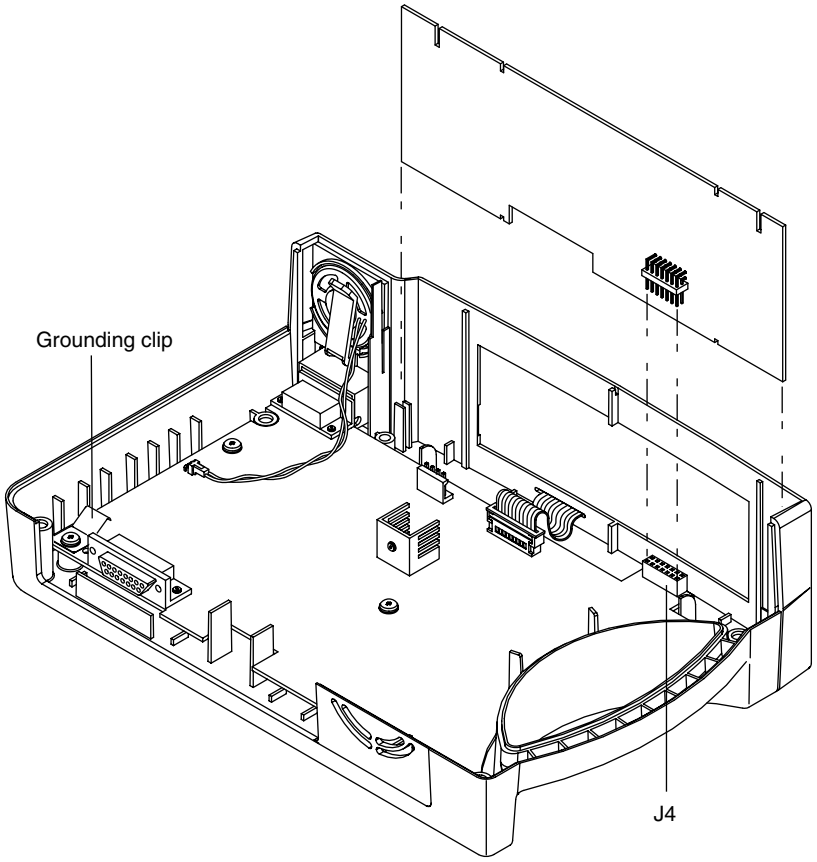


Figure 6-8: Display PCB

Installation

3. Slide the Display PCB into the grooves in the top case, being careful to align the male pins from the Display PCB to connector J4 on the UIF PCB.
4. Complete the procedure in paragraph 6.5.

6.10 UIF PCB REMOVAL/INSTALLATION

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.

2. Lift the Display PCB up to remove it from the top case (Figure 6-8).

3. Disconnect the keypad ribbon cable from J5 of the UIF PCB (Figure 6-8). J5 is a ZIF connector, lift up on the outer shell until it clicks, then remove the ribbon cable from the connector.

4. Disconnect the speaker cable from J3 of the UIF PCB.

5. Remove the five screws in the UIF PCB (Figure 6-9).

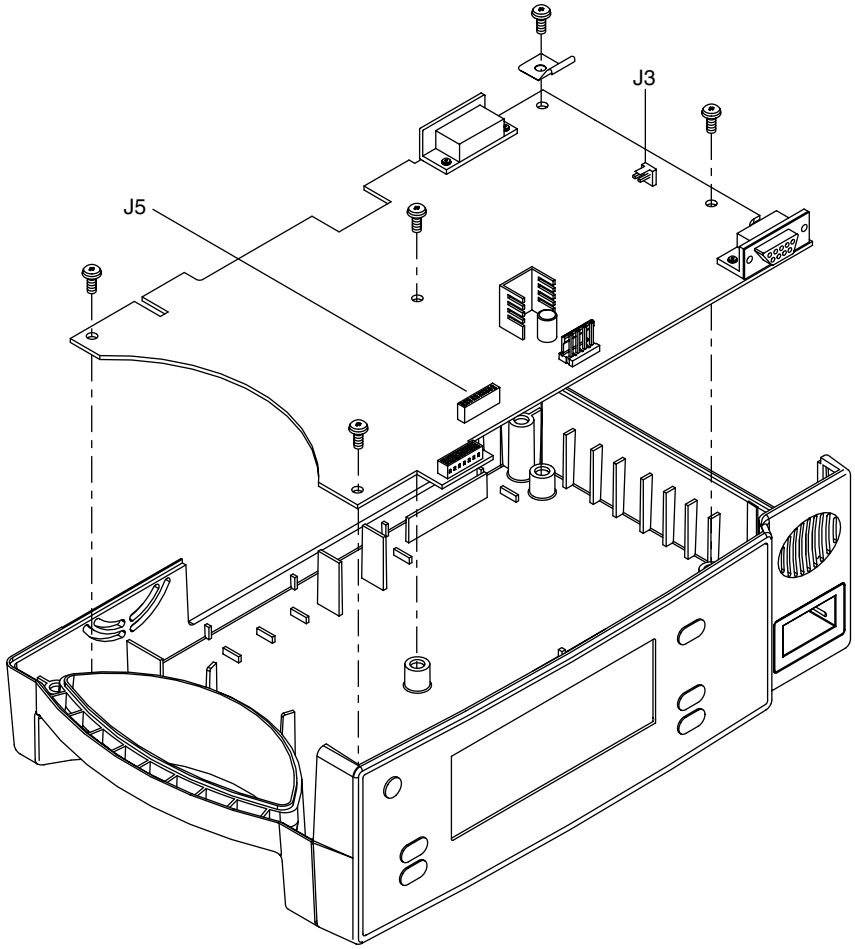


Figure 6-9: UIF PCB

6. Remove the UIF PCB from the top case.

Installation

Caution: When installing the UIF PCB, hand-tighten the five screws to a maximum of 10 inch-pounds. Overtightening could strip out the inserts in the top case, rendering them unusable.

7. Place the UIF PCB in the top case.
8. Install the five screws in the UIF PCB.
9. Lift up on the outer shell of J5 on the UIF PCB until it clicks. Insert the keypad ribbon cable into J5 of the UIF PCB. Slide the outer shell of J5 down until it clicks.
10. Connect the speaker cable to J3 of the UIF PCB.
11. Slide the Display PCB into the grooves in the top case being careful to align the male pins from the Display PCB to connector J4 on the UIF PCB.
12. Complete the procedure in paragraph 6.5.

6.11 ALARM SPEAKER REMOVAL/INSTALLATION

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.
2. Disconnect the speaker wire harness for J3 on the UIF PCB (see Figure 6-10).
3. Pull the holding clip towards the center of the monitor and lift the speaker from the top housing.

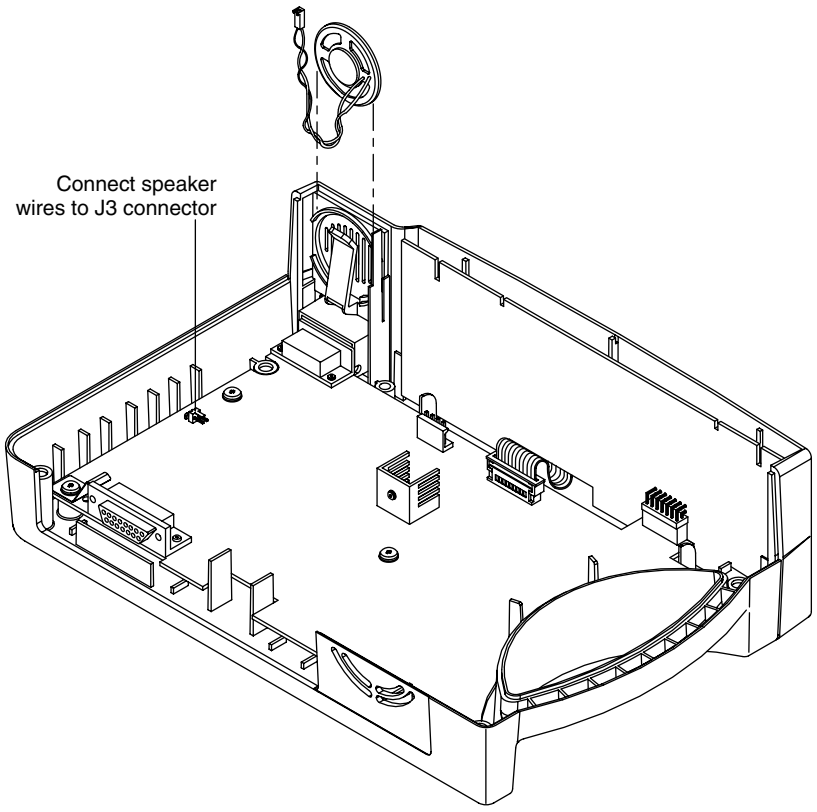


Figure 6-10: Alarm Speaker

Installation

4. Slide the speaker into the plastic holding clip provided in the top housing.
5. Connect the speaker wire harness to J3 on the UIF PCB.
6. Complete the procedure paragraph 6.5.

SECTION 7: SPARE PARTS

7.1 INTRODUCTION

Spare parts, along with part numbers, are shown below. Item numbers correspond to the numbers called out in Figure 7-1.

Item	Description	Part No.
1	Top Case Assembly (Membrane Panel Included)	048428
2	Fuse Drawer	691500
3	Fuses	691032
4	Power Entry Module	691499
5	Power Supply	035200
6	Display PCB	035196
7	Battery	640119
8	Battery Bracket	035307
9	UIF PCB	035192
	Sensor Lock (not shown)	022943
	Alarm Speaker (not shown)	033494
	Ground Clip (not shown)	035400
	Rubber Feet (not shown)	4-003818-00
	Power Cord (not shown)	U.S. 071505 International 901862 U.K. 901863

Figure 7-1 shows the NPB-190 expanded view with item numbers relating to the spare parts list.

Note: Some spare parts have a business reply card attached. When you receive these spare parts, please fill out and return the card.

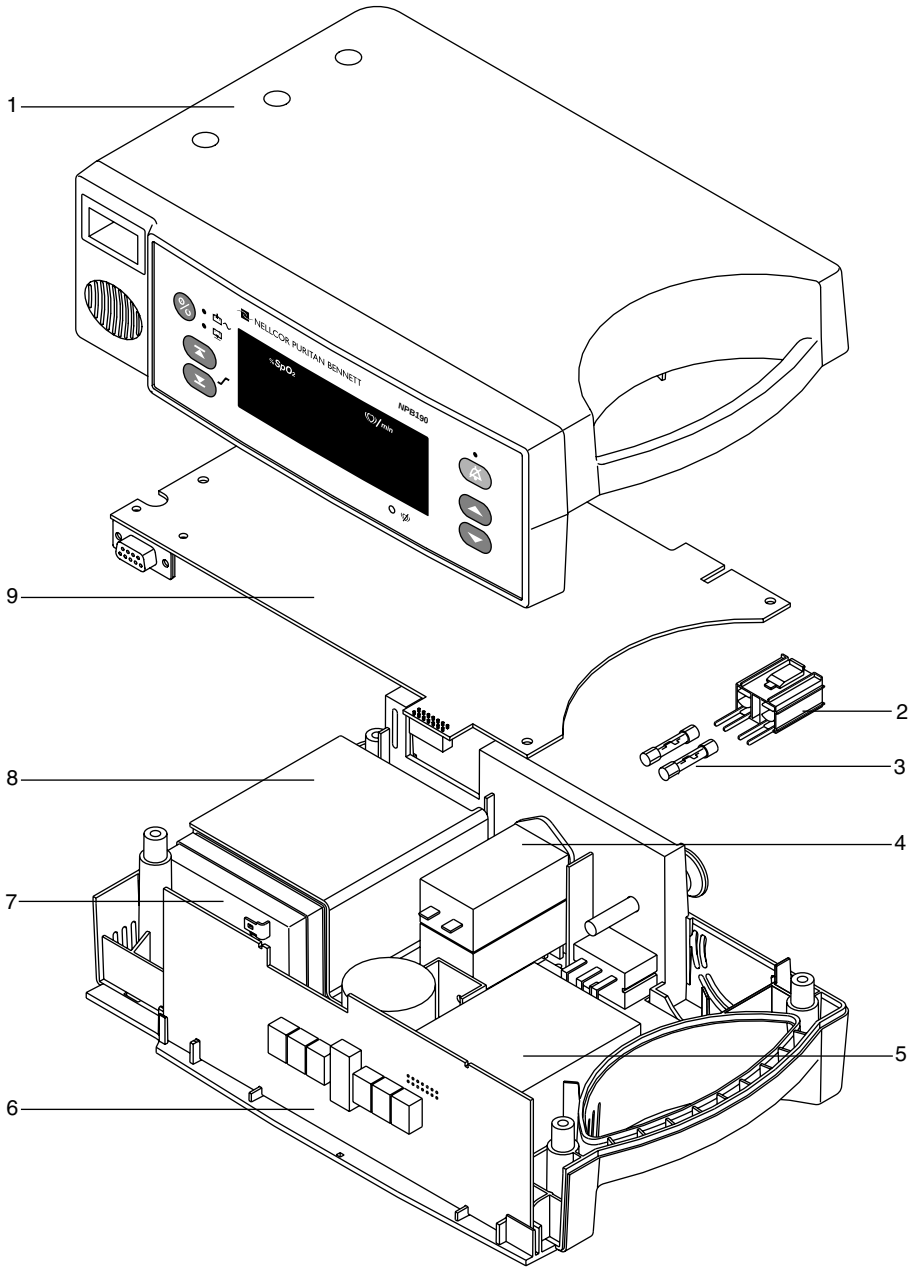


Figure 7-1: NPB-190 Exploded View

SECTION 8: PACKING FOR SHIPMENT

8.1 General Instructions
8.2 Repacking in Original Carton
8.3 Repacking in a Different Carton

To ship the monitor for any reason, follow the instructions in this section.

8.1 GENERAL INSTRUCTIONS

Pack the monitor carefully. Failure to follow the instructions in this section may result in loss or damage not covered by the Mallinckrodt warranty. If the original shipping carton is not available, use another suitable carton; North American customers may call Mallinckrodt Technical Services Department to obtain a shipping carton.

Before shipping the NPB-190, contact Mallinckrodt Technical Services Department for a returned goods authorization (RGA) number. Mark the shipping carton and any shipping documents with the RGA number. European customers not using RGA numbers, should return the product with a detailed, written description of the problem.

8.2 REPACKING IN ORIGINAL CARTON

If available, use the original carton and packing materials. Pack the monitor as follows:

1. Place the monitor in a plastic bag (not shown) and, if necessary, accessory items in original packaging.

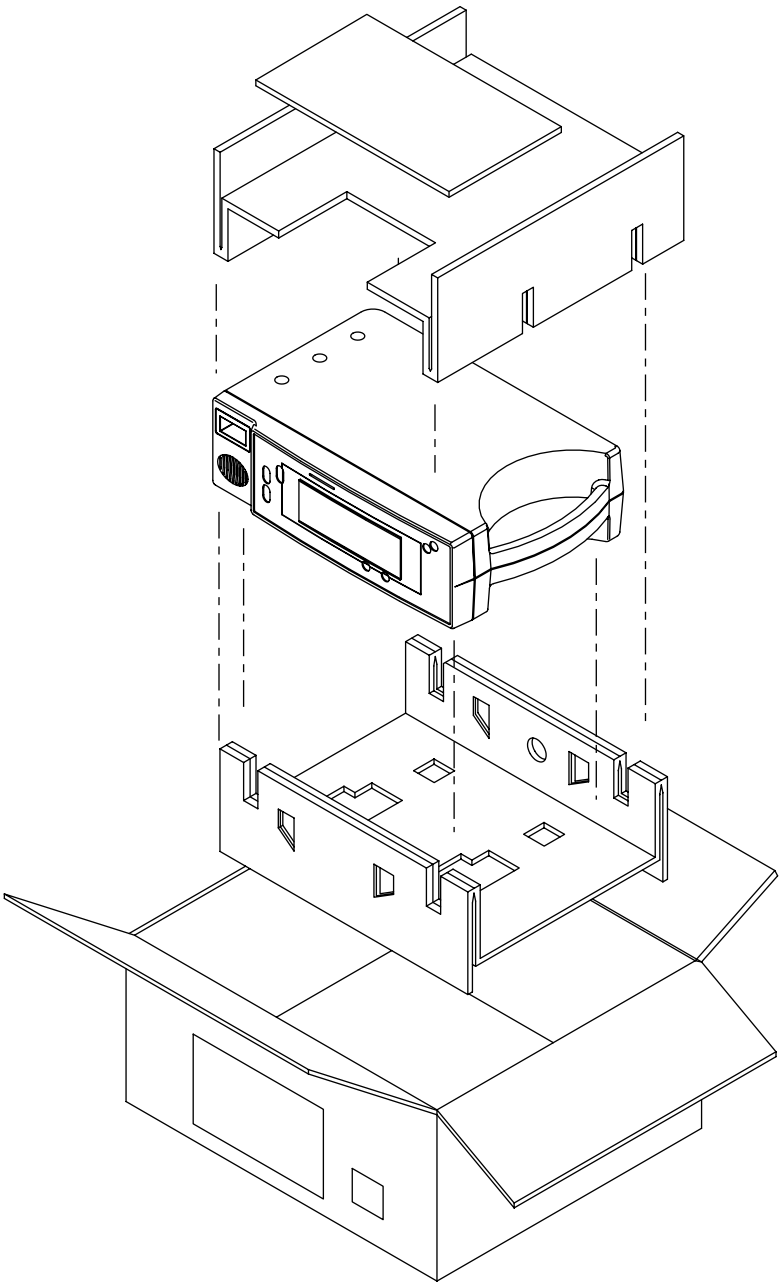


Figure 8-1: Repacking the NPB-190

2. Place in shipping carton and seal carton with packaging tape.

3. Label carton with shipping address, return address and RGA number.

8.3 REPACKING IN A DIFFERENT CARTON

If the original carton is not available, use the following procedure to pack the NPB-190:

1. Place the monitor in a plastic bag.

2. Locate a corrugated cardboard shipping carton with at least 200 pounds per square inch (psi) bursting strength.

3. Fill the bottom of the carton with at least 2 inches of packing material.

4. Place the bagged unit on the layer of packing material and fill the box completely with packing material.

5. Seal the carton with packing tape.

6. Label the carton with the shipping address, return address, and RGA number.

SECTION 9: SPECIFICATIONS

9.1 General
9.2 Electrical
9.3 Physical Characteristics
9.4 Environmental
9.5 Alarms
9.6 Factory Default Settings
9.7 Performance

9.1 GENERAL

Designed to meet safety requirements of:

UL 2601-1 CSA-C22.2 No. 601-1-M90, IEC 601-1 (Class I, type BF)
EMC per EN60601-1-2

9.2 ELECTRICAL

Protection Class

Class I: per IEC 601-1, clause 2.2.4

Degree of Protection

Type BF: per IEC 601-1, clause 2.2.25

Mode of Operation

Continuous

Battery

Type	Rechargeable, sealed lead-acid, internal
Operating time	12 hours minimum on new, fully charged battery
Recharge period	14 hours for full charge
Fuses	2 each 5 X 20 mm Slow Blow. 0.5 amp, 250 volts

AC Power

Selectable by switch	100-120 VAC 50/60 Hz or 200-240 VAC 50/60 Hz

9.3 PHYSICAL CHARACTERISTICS

Dimensions 3.3 in H x 10.4 in W x 6.8 in D
8.4 cm H x 26.4 cm W x 17.3 cm D

Weight 5.5 lb
2.5 kg

9.4 ENVIRONMENTAL

Operating Temperature 5°C to 40°C (+41°F to +104°F)

Storage Temperature

Boxed -20°C to +70°C (-4°F to +158°F)

Unboxed -20°C to +60°C (-4°F to +140°F)

Operating Atmospheric Pressure 700 hPa to 1060 hPa
(20.65 inHg to 31.27 inHg)

Relative Humidity 15% RH to 95% RH, noncondensing

9.5 ALARMS

Alarm Limit Range

% Saturation 20–100%

Pulse Rate 30–250 bpm

9.6 FACTORY DEFAULT SETTINGS

Parameter	Default Setting
SpO2 High Alarm	100%
SpO2 Low Alarm	85%
High pulse rate Alarm	170 bpm
Low pulse rate Alarm	40 bpm
Audible Alarm Volume	Level 5
Audible Alarm Silence Duration	60 seconds
Pulse Beep Volume	Level 4
Communication Protocol	Serial output mode ASCII
Alarm Silence Behavior	Off with a reminder
Baud Rate	9600

9.7 PERFORMANCE

Measurement Range

SpO_2:	0–100%
Pulse/Heart Rate:	20–250 bpm

Accuracy

SpO_2

Adult:	70–100% ± 2 digits 0–69% unspecified
Neonate:	70–100% ± 3 digits 0–69% unspecified

Accuracies are expressed as plus or minus "X" digits (saturation percentage points) between saturations of 70-100%. This variation equals plus or minus one standard deviation (1SD), which encompasses 68% of the population. All accuracy specifications are based on testing the subject monitor on healthy adult volunteers in induced hypoxia studies across the specified range. Adult accuracy is determined with *Oxisensor II* D-25 sensors. Accuracy for neonatal readings is determined with *Oxisensor II* N-25 sensors. In addition, the neonatal accuracy specification is adjusted to take into account the theoretical effect of fetal hemoglobin in neonatal blood on oximetry measurements.

Pulse Rate (optically derived) 20–250 bpm ± 3 bpm

Accuracies are expressed as plus or minus "X" bpm across the display range. This variation equals plus or minus 1 Standard Deviation, which encompasses 68% of the population.

APPENDIX (SERIAL PORT INTERFACE PROTOCOL)

A1 Introduction
A2 Enabling the Serial Port
A3 Connecting to the Serial Port
A4 Real-Time Print Out
A5 Nurse call

A1 INTRODUCTION

When connected to the serial port on the back of the NPB-190, a real-time printout can be obtained. Data lines are printed at 2 second intervals. Column headings will be printed after every 25 lines, or if one of the values in the column heading changes. Changing an alarm limit, for example, would cause a new column heading to be printed. Printouts include patient and device data. A real-time printout cannot be obtained if the unit is operating on battery power. The real-time printout is discussed in more detail in Paragraph A4.

A2 ENABLING THE SERIAL PORT

Real-time data is constantly being sent to the serial port of the NPB-190 when the instrument is operating on AC power. To receive a real-time printout, see Paragraph A3 for instructions to make the connection.

Menu Item 6 is used to change baud rate. Item 6 cannot be accessed when a sensor cable is connected to the instrument. To access menu Item 6, press both the Upper Alarm Limit and the Lower Alarm Limit buttons simultaneously for 3 seconds. Next, press the Upper Alarm Limit button until menu Item 6 is displayed. The baud rate can then be selected by pressing the Adjust Up or Adjust Down button until the desired baud rate is displayed. A baud rate of 9600 is selected as a default value. Other baud rates that can be selected are 2400 and 19200.

A3 CONNECTING TO THE SERIAL PORT

Data is transmitted in the RS-232 format. Only three lines are used; GND is the ground, TxD represents the Transmit Data Line, and RxD is the Receive Data Line. Data can be transmitted a maximum of 25 feet. The pin outs for the serial port are listed in the chart below.

Table A-1: Serial Port Pin Outs

Pin	Line
2	RxD
3	TxD
5,10	GND
11	Nurse call
1, 4, 6-9, 12-15	No Connection

The pin layouts are illustrated in Figure A-1. The conductive shell is used as earth ground. An AMP connector is used to connect to the serial port. Use AMP connector (AMP p/n 747538-1), ferrule (AMP p/n 1-747579-2) and compatible pins (AMP p/n 66570-2).

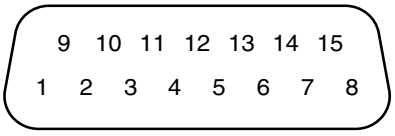


Figure A-1: Serial Port Pin Layout

The serial cable must be shielded. Connectors at both ends of the serial cable must have the shield terminated to the full 360 degrees of the connector's metal shell. If rough handling or sharp bends in the cable is anticipated, use a braided shield.

A4 REAL-TIME PRINTOUT

When a real-time printout is being received, a new line of data is printed every 2 seconds. Every 25th line will be a column heading line. A column heading line will also be printed any time a value in the column heading line is changed. A real-time printout is shown below in Figure A-2

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	
123456789	100	120	220		
123456791	100	124	220		
123456793	100	190	220		
123456795	100	190*	220	PH	
123456797	100	190*	220	PH	
123456799	100	190*	220	PH	
123456801	100	190*	220	PH	
123456803	100	190*	220	PH	
123456805	100	190*	220	PH LB	
123456807	100	190*	220	PH LB	
123456809	100	190*	220	PH LB	
123456811	- - -	- - -	- - -	SD LB	
123456813	- - -	- - -	- - -	SD LB	
123456815	- - -	- - -	- - -	SD	
123456817	- - -	- - -	- - -	SD	
123456819	- - -	- - -	- - -	SD	
123456821	- - -	- - -	- - -	SD	
123456823	- - -	- - -	- - -	PS	
123456825	- - -	- - -	- - -	PS	
123456827	- - -	- - -	- - -	PS	
123456829	- - -	- - -	- - -	PS	
123456831	- - -	- - -	- - -	PS	
123456833	- - -	- - -	- - -	PS	
NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	
123456835	- - -	- - -	- - -	PS	
NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	80-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	
123456837	79*	59*	220	SL PL LB	
123456839	79*	59*	- - -	PS SL PL LB	

Figure A-2: Real-Time Printout

A4.1 Column Headings

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	

To explain the printout, it will be necessary to break it down to its key components. The first two lines of the chart are the column headings shown above. Every 25th line will be a column heading. A column heading is also printed whenever a value of the column heading is changed. There are three column heading lines shown in Figure A-2. Using the top row as the starting point, there are 25 lines before the second column heading is printed. The third column heading was printed because the SpO_2 limits changed from 30-100% to 80-100%.

Printout Source

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	

Data in the highlighted box above represents the source of the printout, in this case the NPB-190.

Software Revision Level

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	

The next data field tells the user the software level, (Version 1.0.0) and a software verification number (CRC XXXX). Neither of these numbers should change during normal operation. The numbers will change if the monitor is serviced and receives a software upgrade.

Alarm Limits

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	

The last data field in the top line indicates the high and low alarm limits for %SpO_2 and for the pulse rate (PR). In the example above, the low alarm limit for SpO_2 is 30% and the high alarm limit is 100%. Pulse rate alarm limits are: low 100 bpm, and high 180 bpm.

Column Headings

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	

Actual column headings are in the second row of the column heading line. Patient data presented in the chart is, from left to right: the time that the chart was printed, the current %SpO_2 value being measured, current pulse rate in beats per minute (bpm), current pulse amplitude (PA), and the operating status of the NPB-190.

A4.2 Patient Data and Operating Status

Time Tag

Time Tag	%SpO2	PR (bpm)	PA	Status
123456789	100	120	220	

Time Tag does not represent a real-time clock. The number beneath the Time Tag heading represents time, in seconds, since the unit was initialized at the factory. This number will increase in size throughout the life of the monitor.

Patient Data

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	
123456795	100	190*	220	PH	

Patient data are highlighted in the display above. Parameter values are displayed directly beneath the heading for each parameter. In this example, the %SpO_2 is 100, and the pulse rate PR is 190 beats per minute. The "*" next to the 190 indicates that 190 beats per minute is outside of the alarm limits, indicated in the top row, for pulse rate. If no data for a parameter is available three dashes (- - -) will be displayed in the printout.

PA is an indication of pulse amplitude. The number can range from 0 to 254 and will typically range around 45. There are no alarm parameters for this value. It can be used for trending information. It is an indication of a change in pulse volume, pulse strength, or circulation.

NPB-190	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
Time Tag	%SpO2	PR (bpm)	PA	Status	
123456795	100	190*	220	PH	

The Status column indicates alarm conditions and operating status of the NPB-190. A Pulse High alarm is indicated by the PH in this example. The status column can have as many as four codes displayed in one line of data. A complete listing of the status codes is listed in Table A-2.

Table A-2: Status Codes

Code	**Meaning**
LB	**L**ow **B**attery
AS	**A**larm **S**ilence
AO	**A**larm **O**ff
SD	**S**ensor **D**isconnect
PS	**P**ulse **S**earch
LP	**L**oss of **P**ulse
SH	**S**at **H**igh Limit Alarm
SL	**S**at **L**ow Limit Alarm
PH	**P**ulse rate **H**igh Limit Alarm
PL	**P**ulse rate **L**ow Limit Alarm

Note: A Sensor Disconnect will also cause three dashes (- - -) to be displayed in the patient data section of the printout.

A5 NURSE CALL

A Nurse Call signal can be obtained by connecting to the serial port. This function is only available when the instrument is operating on AC power. Nurse Call will be disabled when the unit is operating on battery power, or if the audible alarm is turned off or silenced. The remote location will be signaled anytime there is an active audible alarm.

Pin 11 on the serial port is the Nurse Call signal and pin 10 is ground (see Figure A-1). When there is no alarm condition, the voltage between pins 10 and 11 will be -5 to -12 VDC. Whenever there is an active audible alarm condition, the output between pins 10 and 11 will be +5 to +12 VDC.

TECHNICAL SUPPLEMENT

S1 Introduction
S2 Oximetry Overview
S3 Circuit Analysis
S4 Functional Overview
S5 AC Input
S6 Power Supply PCB
S7 Battery
S8 User Interface PCB
S9 Front Panel Display PCB and Controls
S10 Schematics

S1 INTRODUCTION

This Technical Supplement provides the reader with a discussion of oximetry principles and a more in-depth discussion of NPB-190 circuits. A functional overview and detailed circuit analysis is supported by block and schematic diagrams. The schematic diagrams are located at the end of this supplement.

S2 OXIMETRY OVERVIEW

The NPB-190 is based on the principles of spectrophotometry and optical plethysmography. Optical plethysmography uses light absorption technology to reproduce waveforms produced by pulsatile blood. The changes that occur in the absorption of light due to vascular bed changes are reproduced by the pulse oximeter as plethysmographic waveforms.

Spectrophotometry uses various wavelengths of light to qualitatively measure light absorption through given substances. Many times each second, the NPB-190 passes red and infrared light into the sensor site and determines absorption. The measurements that are taken during the arterial pulse reflect absorption by arterial blood, nonpulsatile blood, and tissue. The measurements that are obtained between arterial pulses reflect absorption by nonpulsatile blood and tissue.

By correcting "during pulse" absorption for "between pulse" absorption, the NPB-190 determines red and infrared absorption by pulsatile arterial blood. Because oxyhemoglobin and deoxyhemoglobin differ in red and infrared absorption, this corrected measurement can be used to determine the percent of oxyhemoglobin in arterial blood: SpO2 is the ratio of corrected absorption at each wavelength.

S2.1 Functional Versus Fractional Saturation

The NPB-190 measures functional saturation, that is, oxygenated hemoglobin expressed as a percentage of the hemoglobin that is capable of transporting oxygen. It does not detect significant levels of dyshemoglobins. In contrast, hemoximeters such as the IL482 report fractional saturation, that is, oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including measured dysfunctional hemoglobins.

Consequently, before comparing NPB-190 measurements with those obtained by an instrument that measures fractional saturation, measurements must be converted as follows:

$$\text{functional saturation} = \text{fractional saturation} \times \frac{100}{100-(\%\ \text{carboxyhemoglobin} + \%\text{methemoglobin})}$$

S2.2 Measured Versus Calculated Saturation

When saturation is calculated from a blood gas measurement of the partial pressure of arterial oxygen (PaO_2), the calculated value may differ from the NPB-190 SpO_2 measurement. This is because the calculated saturation may not have been corrected for the effects of variables that can shift the relationship between PaO_2 and saturation.

Figure S2-1 illustrates the effect that variations in pH, temperature, partial pressure of carbon dioxide (PCO_2), and concentrations of 2,3-DPG and fetal hemoglobin may have on the oxyhemoglobin dissociation curve.

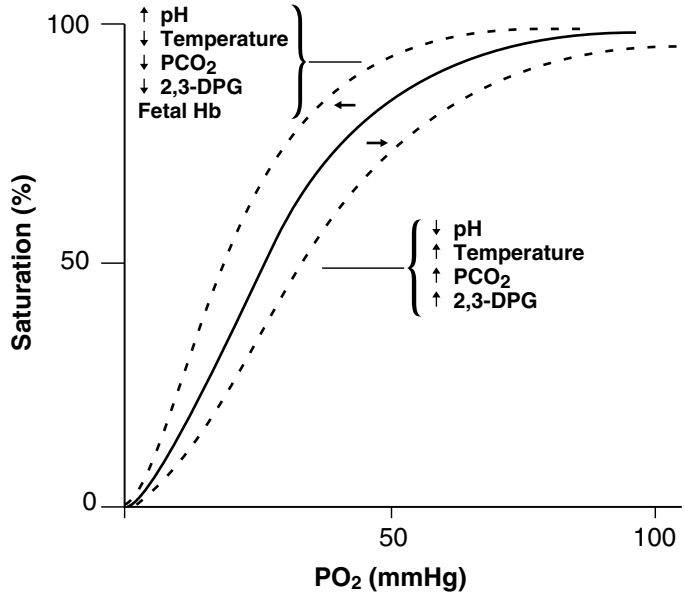


Figure S-1: Oxyhemoglobin Dissociation Curve

S3 CIRCUIT ANALYSIS

The following paragraphs discuss the operation of each of the printed circuit boards within the NPB-190 pulse oximeter. (Refer to the appropriate schematic diagram at the end of this supplement, as necessary.)

S4 FUNCTIONAL OVERVIEW

The monitor functional block diagram is shown in Figure S4-1. Most of the functions of the NPB-190 are performed on the UIF PCB. Functions on the UIF PCB include the SPO_2 module, PIC, CPU, and Memory. Other key components of the NPB-190 are the Power Entry Module (PEM), Power Supply, and the Display PCB.

The Display module consists of the LED display and the Membrane Panel. Contained on the Membrane Panel are enunciators and push buttons, allowing the user to access information and to select various available parameters. The Display PCB contains; SpO_2, heart rate, and Blip Bar LEDs, and their associated driver circuits.

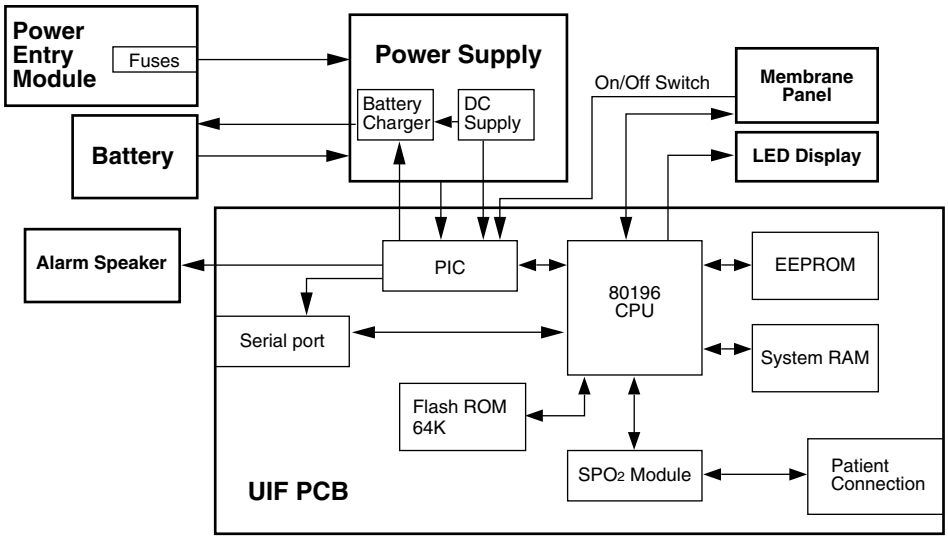


Figure S-2: NPB-190 Functional Block Diagram

S5 AC INPUT

A selector switch on the back of the NPB-190 allows the user to connect the monitor to AC power ranging from 100 VAC to 240 VAC. The switch has two positions, one for 100 VAC through 120 VAC and one for 200 VAC through 240 VAC. Verify that the switch selection matches the AC power at your location before plugging the monitor into an AC outlet.

AC power enters the NPB-190 through the Power Entry Module (PEM). Both the Line and Neutral lines are protected by a 0.5 amp fuse. These user-accessible fuses are located in a fuse drawer, which is part of the PEM located on the back of the monitor.

S6 POWER SUPPLY PCB THEORY OF OPERATION

The NPB-190 uses an unregulated linear power supply. This power supply provides the DC power needed to charge the battery and to power the User InterFace PCB (UIF). Electro Static Discharge (ESD) protection is also provided by the power supply.

AC power from the PEM is passed through a step-down transformer, T2, which has two primary and two secondary windings. If switch SW1 on the back of the monitor is in the 120 VAC position, the primary windings are in parallel. The primary windings are in series if SW1 is in the 240 VAC position.

Each secondary winding is fused with a 2.0 amp fuse (F1 and F2). If a short circuit should occur in the DC circuitry, these fuses prevent the transformer from overheating. The output of the transformer varies, depending on load and input. Voltage measured between the outlet of a secondary winding and ground can be from 6 to 20 VAC. High frequency noise from the AC line and from the UIF PCB is filtered by C6 and C8 before passing through the bridge rectifier.

The bridge rectifier provides the DC power used in the NPB-190. The positive output is the Main_DC ranging from 7 to 18 VDC. This positive voltage is used for the battery circuit and to power the UIF PCB.

S6.1 Battery Circuits

Two circuits are included in this section of the Power Supply PCB. One circuit is used to charge the battery, and the other circuit provides battery protection.

Charging Circuit
The Power Supply will charge the battery any time the NPB-190 is connected to AC power even if the monitor is not turned on. The voltage applied to the battery is 6.8 ± 0.15 VDC and is current limited to 400 ± 80 mA.

Battery Protection
Two types of battery protection are provided by the Power Supply; protection for the battery and protection from the battery.

SW2 is a resettable component that protects the battery. SW2 opens and turns the charging circuit off if the temperature of the battery rises above 50∞ C. If the output of the battery exceeds 2.5 amps, F3 opens. F3 protects the battery from a short to ground of the battery output. F3 cannot be reset.

Protection from the battery is provided in case the battery is connected backwards. Should this happen, the output of the battery is shorted to ground through CR3. This provides protection for other circuits in the monitor.

S7 BATTERY

A lead-acid battery is used in the NPB-190. It is rated at 6 VDC 4 amphours. When new and fully charged, the battery will operate the monitor for 12 hours. A new battery will last 15 minutes from the time the low battery alarm is declared until the unit is shut down due to battery depletion.

The battery can withstand 400 charge/discharge cycles. Recharging the battery to full capacity takes 14 hours.

Change over from AC to battery power will not interrupt the normal monitoring operation of the NPB-190. When the unit is running on battery power, the serial port will be turned off along with the Nurse Call.

S8 USER INTERFACE PCB (UIF)

The UIF PCB is the heart of the NPB-190. All functions except the unregulated DC power supply, display, and keypad reside on the UIF PCB. The following text covers the key circuits of the UIF PCB.

S8.1 Regulated DC Power Supply

The UIF PCB receives the Main_DC unregulated voltage of 7 to 18 VDC from the Power Supply, or 5.8 to 6.5 VDC from the internal battery. The Power Supply on the UIF PCB generates +10.0, -5.0 and +5.0 VDC.

S8.2 Controlling Hardware

Two microprocessors reside on the UIF PCB. The CPU is an Intel 80C196KC (196) running at 10MHz. The second microprocessor is referred to as the PIC and is controlled by the CPU.

CPU
The 196 is the main controller of the NPB-190. The 196 controls the front panel display, data storage, and the SpO_2 function. Serial port communication is controlled by the 196 with the exception of the Nurse Call. The user interface is controlled by the CPU with the exception of the power button.

The SpO_2 function is controlled by a pulse width modulator (PWM) function built into the processor. PWM signals are sent to control the intensity of the LEDs in the sensor and to control the gain of the amplifiers receiving the return signals from the photodetector in the sensor.

Analog signals are received from the SpO_2 circuit on the UIF PCB. An A/D function in the 196 converts these signals to digital values for $\%SpO_2$ and heart rate. The values are then displayed and stored.

User's interface includes the front panel display and the keypad. By pressing any of five keys on the keypad the operator can access different functions of the NPB-190 (the power switch is not controlled by the 196). The 196 will recognize the keystroke and make the appropriate change to the monitor display to be viewed by the operator. Any changes made by the operator are used by the

monitor until it is turned off. Default values will be restored when the unit is power-on again.

Patient data is stored by the NPB-190 and can be downloaded to a printer through the serial port provided on the back of the monitor. An in-depth discussion of the serial port is covered in the Appendix of this manual.

PIC
Primary responsibilities of the PIC include monitoring and controlling the NPB-190ís power, and generating sounds.

Since the PIC monitors and controls system power, the Power On/Standby switch is interfaced with the PIC. When the Power On/Standby switch is pressed, the PIC sends power to the circuits within the NPB-190. The PIC will determine if the unit is running on AC, or battery power, and illuminate the proper indicator. The serial port and nurse call functions are disabled by the PIC if the unit is running on battery power.

Battery voltage is checked periodically by the processor. A signal from the processor turns the charging circuit off to allow this measurement to be taken. If the processor determines that the battery voltage is below 5.85 ± 0.1 VDC, a low battery alarm is declared by the PIC. If battery voltage on the UIF PCB is measured below 5.67 ± 0.1 DCV, the monitor will display an error code and sound an audible alarm. (Voltages measured at the battery will be slightly higher than the values listed above). The user will be unable to begin monitoring a patient if the battery voltage remains below this point. If either event occurs, plug the unit into an AC source for 14 hours to allow the battery to fully recharge.

When the NPB-190 is powered by AC, the nurse call function is available. If no alarm conditions exist, the output will be -5 to -12 VDC. Should an alarm condition occur, the output will be +5 to +12 VDC.

When the CPU sends a tone request, three items are used to determine the tone that is sent by the PIC to the speaker. First, pulse tones change with the %SpO_2 value being measured. The pulse beep tone will rise and fall with the measured %SpO_2 value. Second, three levels of alarms, each with its own tone, can occur, High, Medium, and Low priority. Third, the volume of the alarm is user adjustable. Alarm volume can be adjusted from level 1 to level 10, with level 10 being the highest volume.

A time clock is provided by the NPB-190. The PIC is powered at all times to support this function. To conserve power, the PIC enters a low-power sleep mode when the instrument is powered down.

S8.3 Sensor Output/LED Control

The SpO_2 analog circuitry provides control of the red and IR LEDs such that the received signals are within the dynamic range of the input amplifier. Because excessive current to the LEDs will induce changes in their spectral output, it is sometimes necessary to increase the received signal channel gain. To that point, the CPU controls both the current to the LEDs and the amplification in the signal channel.

At initialization of transmission, the LED's intensity level is based on previous running conditions, and the transmission intensity is adjusted until the received signals match the range of the A/D converter. If the LEDs reach maximum output without the necessary signal strength, the PWMs will increase the channel gain. The PWM lines will select either a change in the LED current or signal gain, but will not do both simultaneously.

The LED drive circuit switches between red and IR transmission and disables both for a time between transmissions in order to provide a no-transmission reference. To prevent excessive heat build-up and prolong battery life, each LED is on for only a small portion of the duty cycle. Also, the frequency of switching is well above that of motion artifact and not a harmonic of known AC transmissions. The LED switching frequency is 1.485 kHz. The IR transmission alone, and the red transmission alone, will each be on for about one-fifth of the duty cycle; this cycle is controlled by the CPU.

S8.4 Input Conditioning

Input to the SpO_2 analog circuit is the current output of the sensor photodiode. In order to condition the signal current, it is necessary to convert the current to voltage.

Because the IR and red signals are absorbed differently by body tissue, their received signal intensities are at different levels. Therefore, the IR and red signals must be demodulated and then amplified separately in order to compare them to each other. Demultiplexing is accomplished by means of two circuits that alternately select the IR and red signal. Selection of the circuits is controlled by two switches that are coordinated with the IR and red transmissions. A filter with a large time constant follows to smooth the signal and remove noise before amplification.

S8.5 Signal Gain

The separated IR and red signals are amplified so that their DC values are within the range of the A/D converter. Because the received IR and red signals are typically at different current levels, the signal gain circuits provide independent amplification for each signal as needed. The gain in these circuits is adjusted by means of the PWM lines from the CPU.

After the IR and red signals are amplified, they are filtered to improve the signal-to-noise ratio and clamped to a reference voltage to prevent the combined AC and DC signal from exceeding an acceptable input voltage from the A/D converter.

S8.6 Variable Gain Circuits

The two variable gain circuits are functionally equivalent. The gain of each circuit is contingent upon the signal's received level and is controlled to bring each signal to approximately 3.5 V. Each circuit uses an amplifier and one switch in the triple SPDT analog multiplexing unit.

S8.7 AC Ranging

In order to achieve a specified level of oxygen saturation measurement and to still use a standard type combined CPU and A/D converter, the DC offset is subtracted from each signal. The DC offsets are subtracted by using an analog switch to set the mean signal value to the mean of the range of the A/D converter whenever necessary. The AC modulation is then superimposed upon that DC level. This is also known as AC ranging.

Each AC signal is subsequently amplified such that its peak-to-peak values span one-fifth of the range of the A/D converter. The amplified AC signals are then filtered to remove the residual effects of the PWM modulations and, finally, are input to the CPU. The combined AC and DC signals for both IR and red signals are separately input to the A/D converter.

S9 FRONT PANEL DISPLAY PCB AND CONTROLS

S9.1 Display PCB

Visual patient data and monitor status is provided by the Front Panel Display PCB. At power up, all indicators are illuminated to allow verification of their proper operation.

There are two sets of three 7-segment displays. One set displays %SpO_2 and the other displays pulse rate. A decimal point immediately to the right of either display indicates that an alarm limit for that parameter is no longer set at the power on default value.

In between the two 7-segment displays is a 10-segment blip bar. The blip bar illuminates with each pulse beat. The number of segments illuminated indicate the relative signal strength of the pulse beat. A tone will accompany each pulse beat. The sound of the tone will change pitch with the %SpO_2 level being measured.

Four LEDs and icons are also located on the Front Panel Display PCB. An LED illuminated next to an icon indicates a function that is active. Functions indicated by the LEDs are AC/Battery Charging, Low Battery, Alarm Silence active, and Pulse Search.

S9.2 Membrane Keypad

A membrane keypad is mounted as part of the top case. A ribbon cable from the keypad passes through the top case and connects to the UIF PCB. Six keys allow the operator to access different functions of the NPB-190.

These keys allow the user to select and adjust the alarm limits, cycle power to the unit, and to silence the alarm. Alarm volume and alarm silence duration can also be adjusted via the keypad. A number of other functions can be accessed by pressing the Upper and Lower Alarm Limit buttons simultaneously and then selecting the desired option with the Adjust Up or Adjust Down button. These functions are discussed in greater detail in Section 4.

S10 SCHEMATIC DIAGRAMS

The following schematics are included in this section:

Figure	Description
S-3	Front End Red/IR Schematic Diagram
S-4	Front End LED Drive Schematic Diagram
S-5	Front End Output Schematic Diagram
S-6	Front End Power Supply Schematic Diagram
S-7	Isolation Barrier EIA-232 Port Schematic Diagram
S-8	CPU Core Schematic Diagram
S-9	PIC and Speaker Schematic Diagram
S-10	Indicator Drive Schematic Diagram
S-11	Core Power Supply Schematic Diagram
S-12	Parts Locator Diagram for UIF PCB
S-13	Display PCB Schematic Diagram
S-14	Parts Locator Diagram for Display PCB
S-15	Power Supply Schematic Diagram
S-16	Parts Locator Diagram for Power Supply PCB

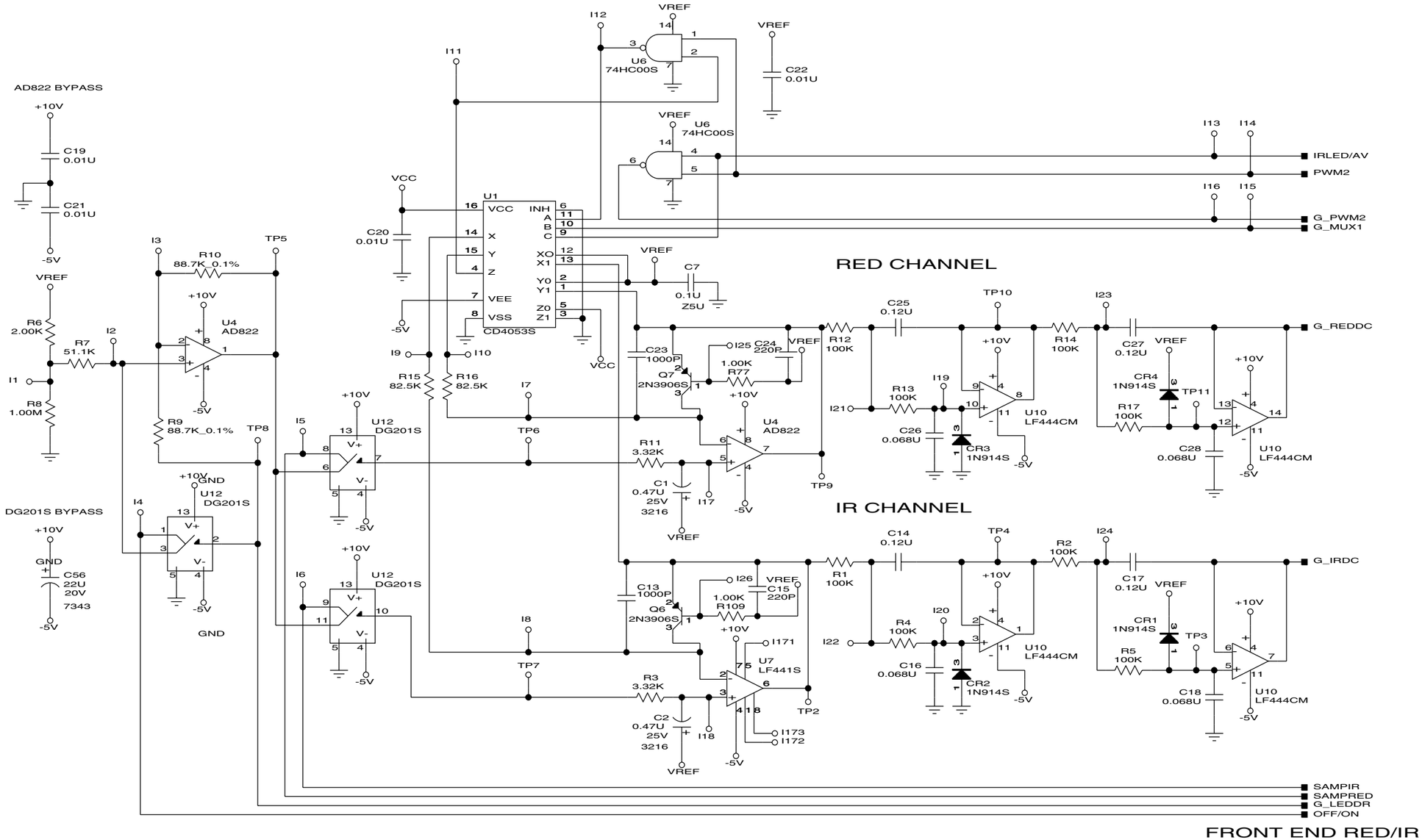


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Figure S-3
Front End Red/IR Schematic Diagram (1 of 10)

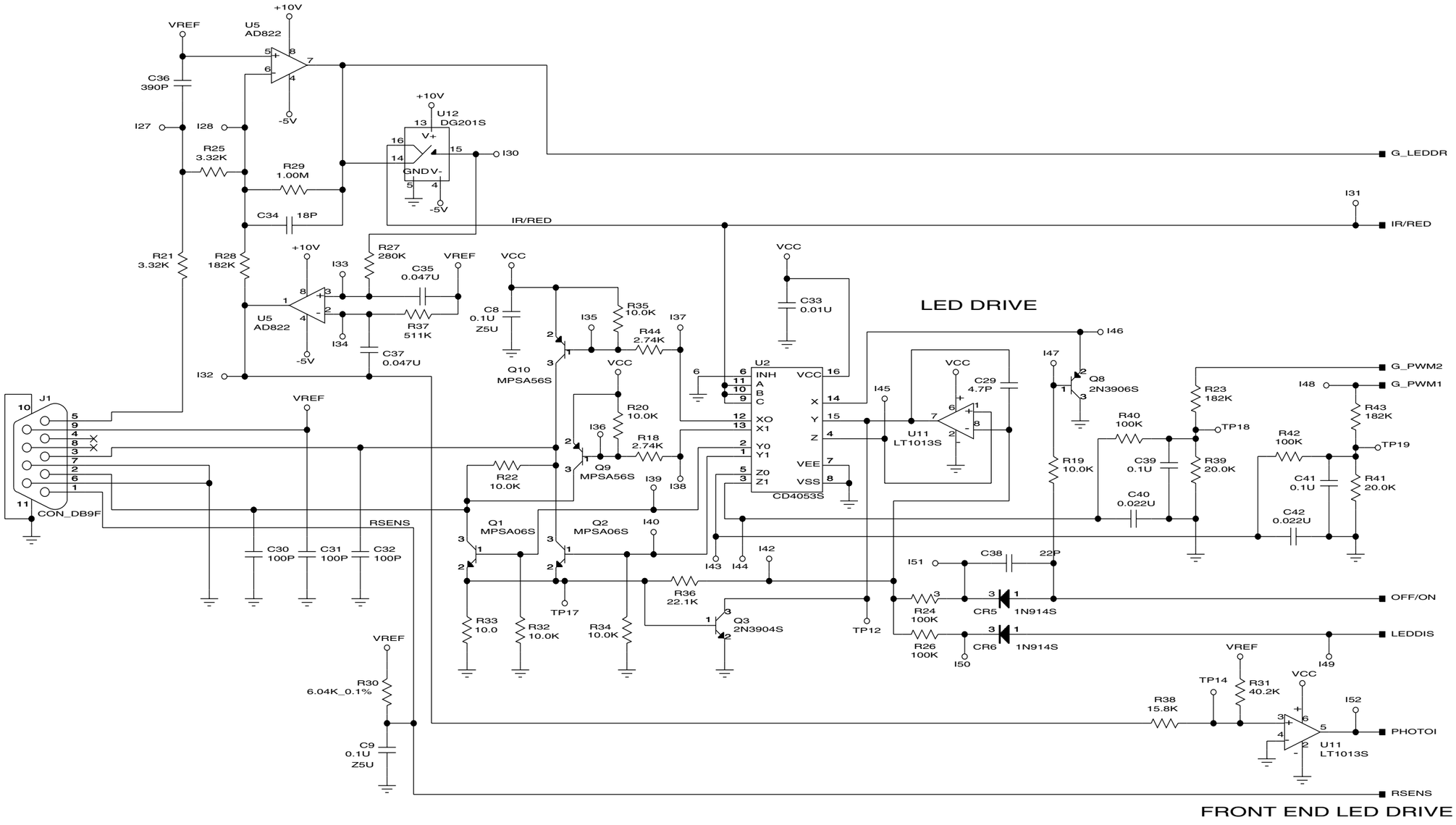

Figure S-4
Front End LED Drive Schematic Diagram (2 of 10)

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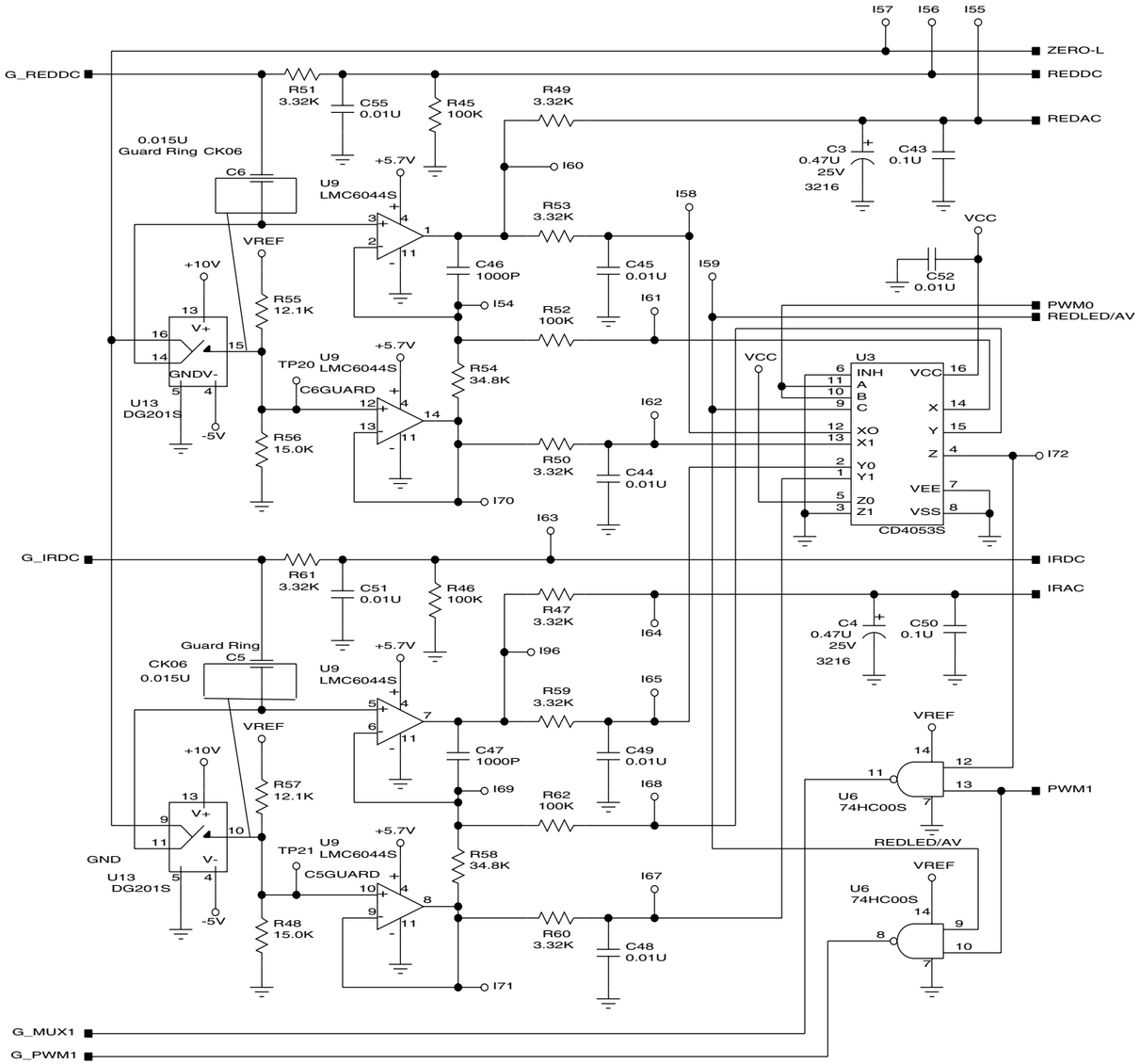
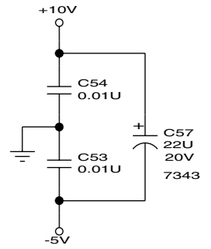


DG201S BYPASS



DG201S SPARES

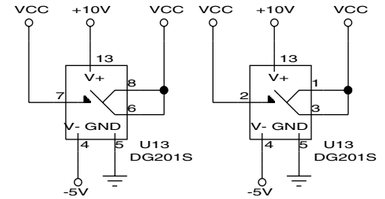


Figure S-5
Front End Output Schematic Diagram (3 of 10)

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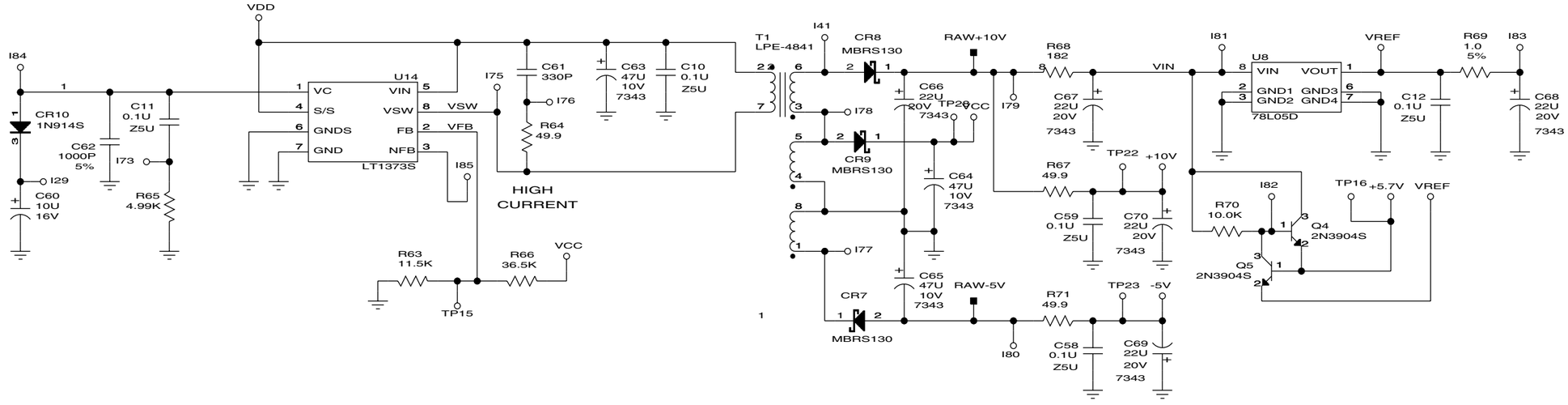

Figure S-6
Front End Power Supply Schematic Diagram (4 of 10)

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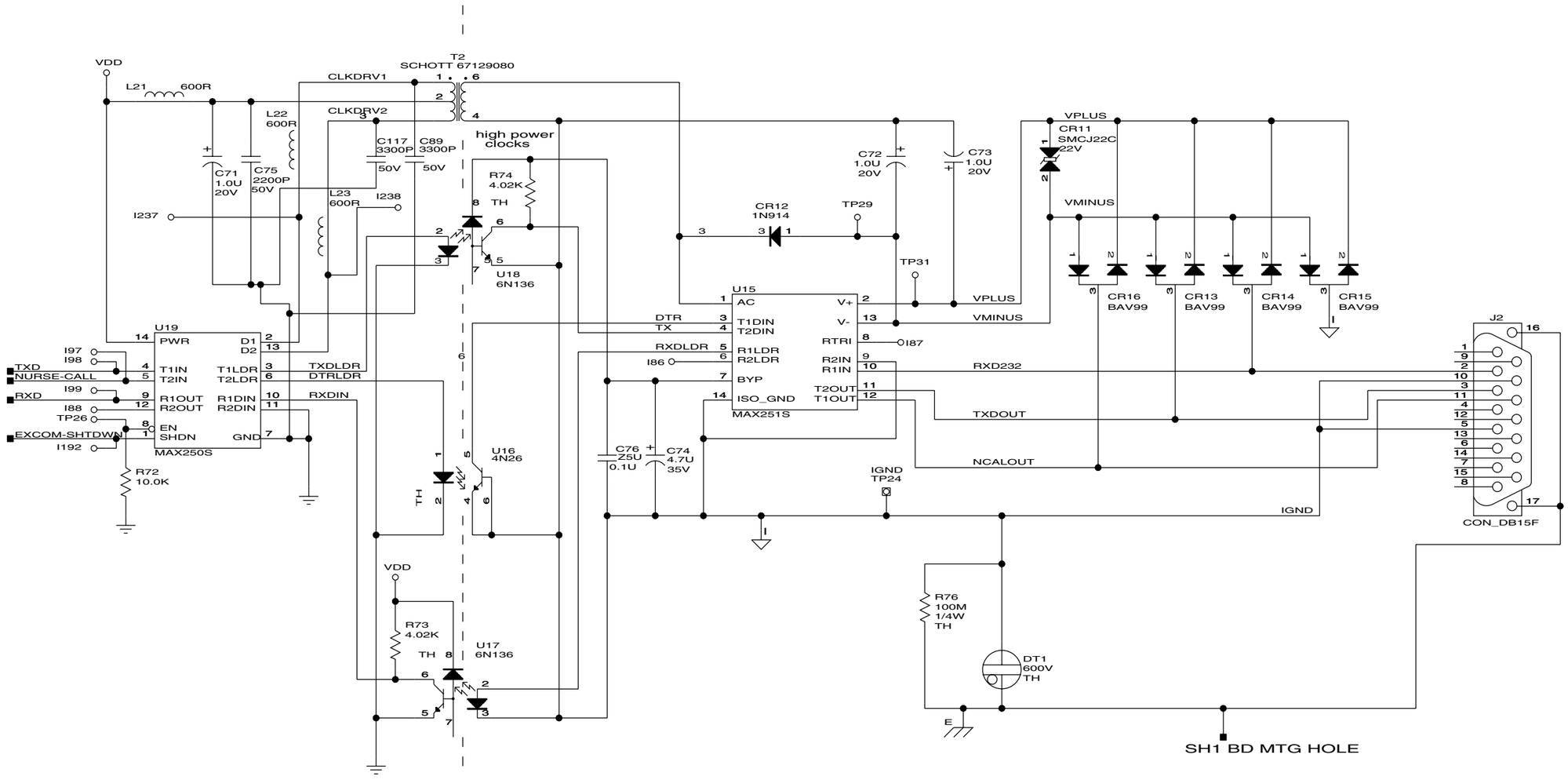

ISOLATION BARRIER
EIA-232 Port

Figure S-7
Isolation Barrier EIA-232 Port Schematic Diagram (5 of 10)

035191

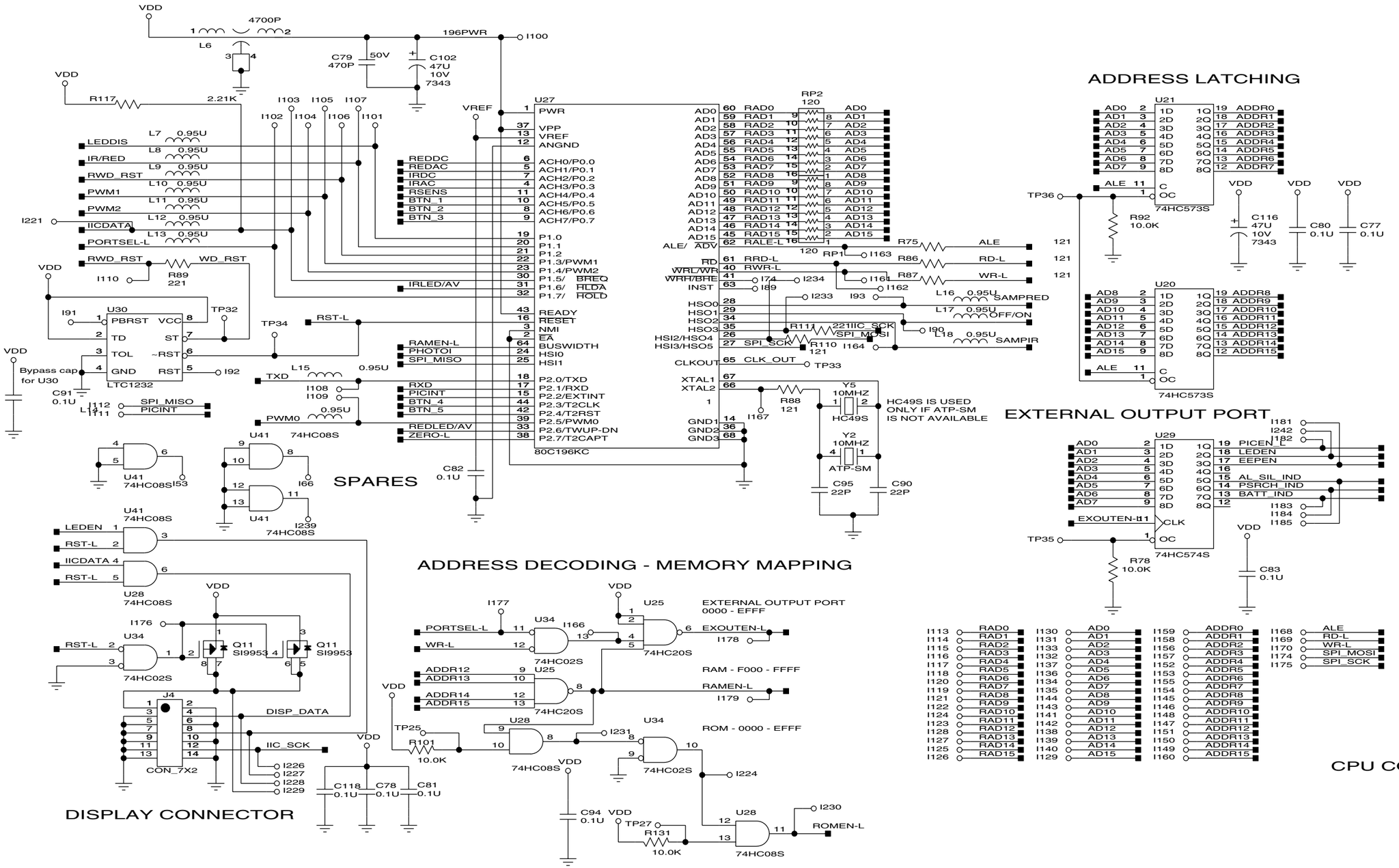

Figure S-8
CPU Core Schematic Diagram (Sheet 6 of 10)

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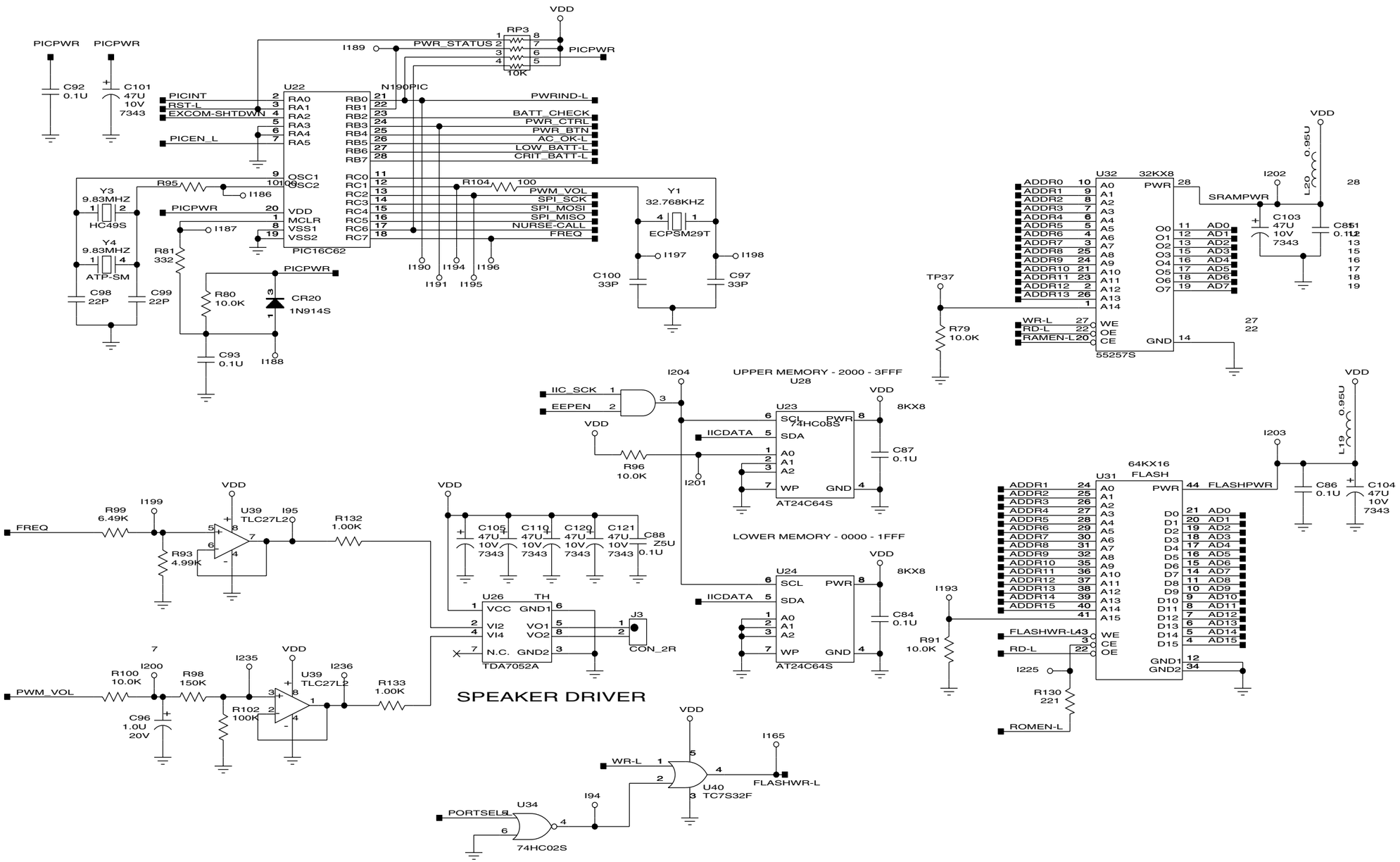

Figure S-9
PIC and Speaker Schematic Diagram (Sheet 7 of 10)

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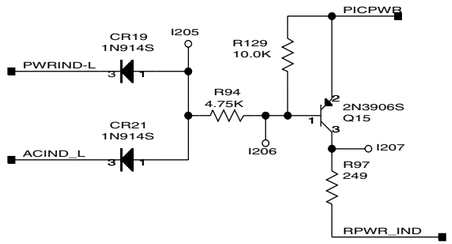
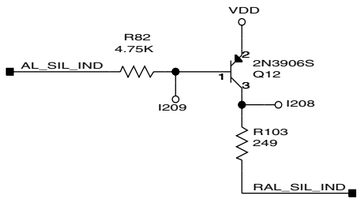
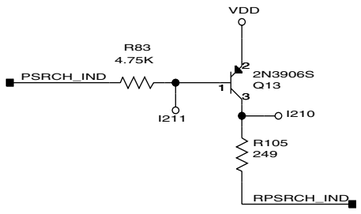


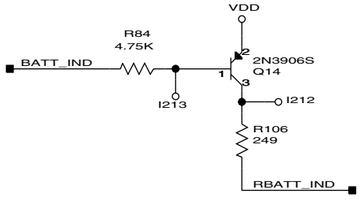
AC LED DRIVE CIRCUIT



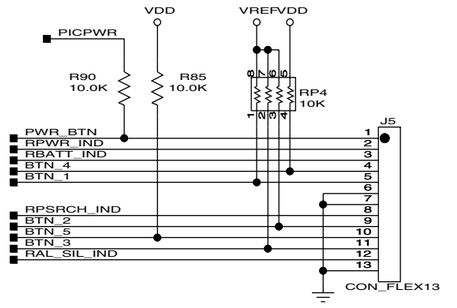
ALARM SILENCE INDICATOR DRIVE CKT



PULSE SEARCH IND DRIVE CKT



BATTERY IND DRIVE CKT



MEMBRANE PANEL CONNECTOR

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Figure S-10
Indicator Drive Schematic Diagram (Sheet 8 of 10)

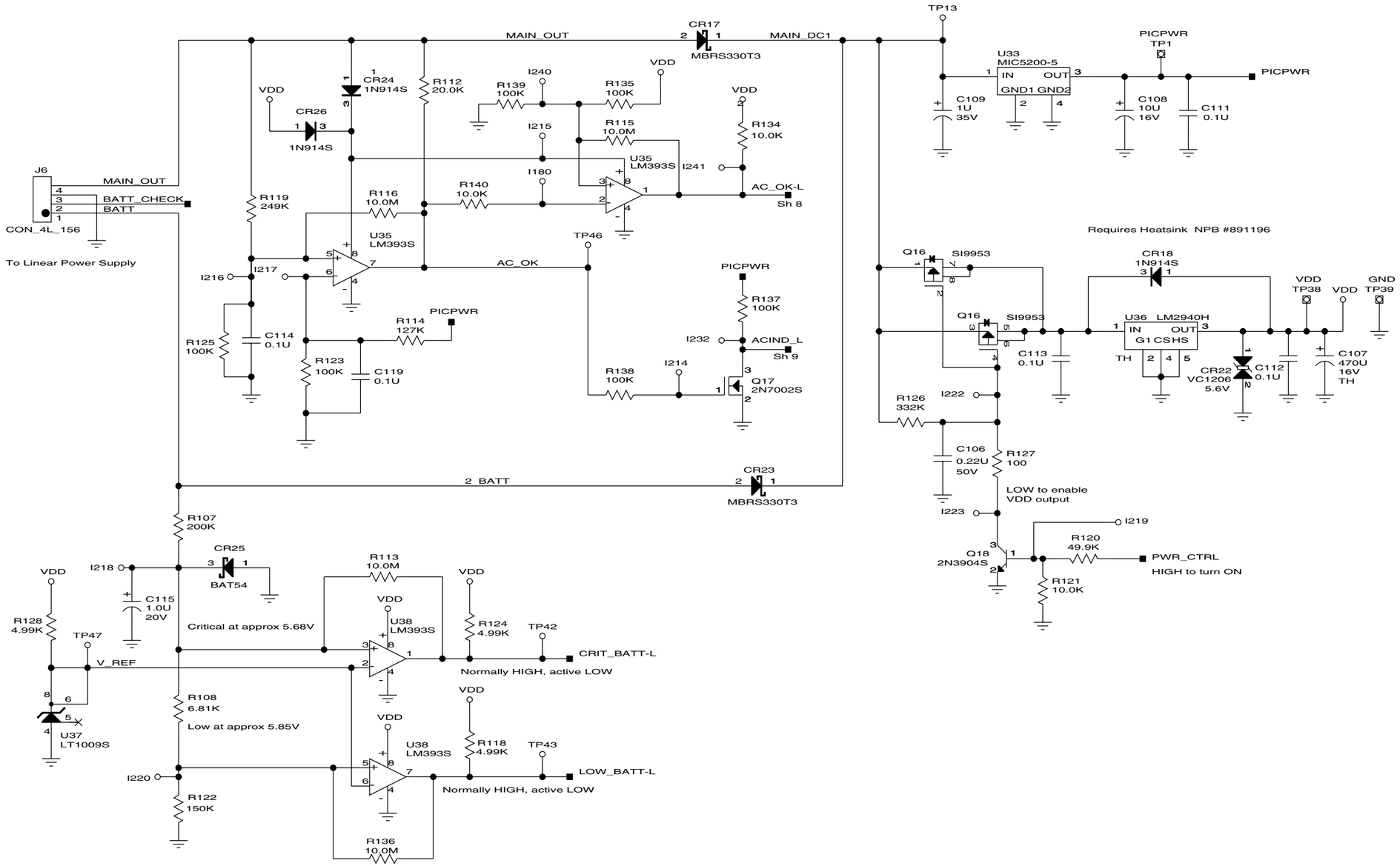

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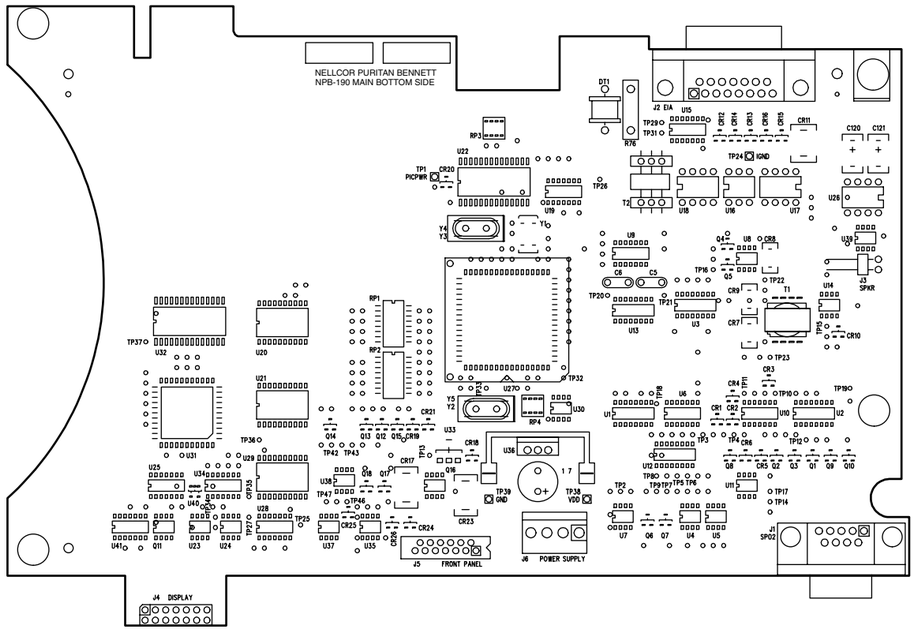
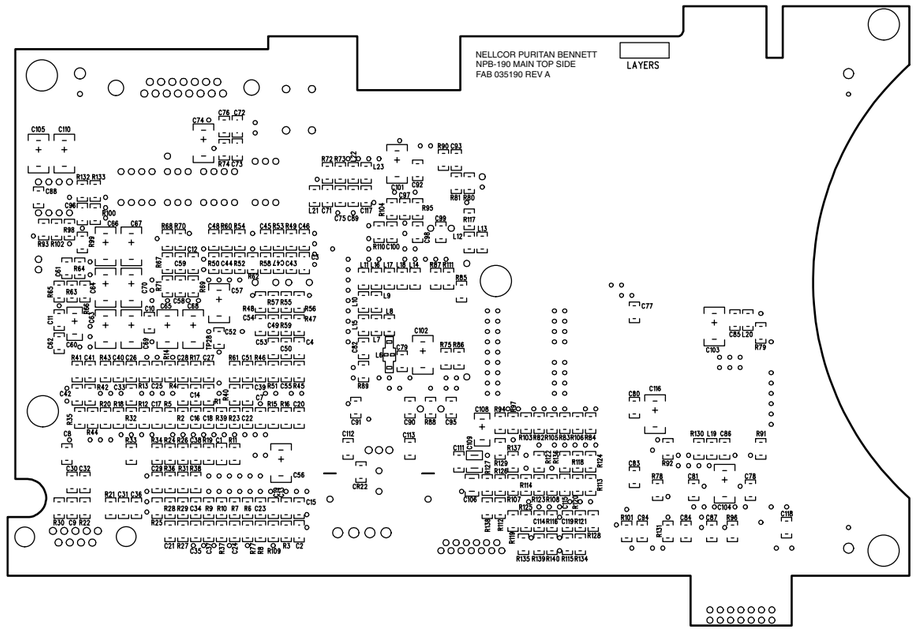
Figure S-11
Core Power Supply Schematic Diagram (9 of 10)



TOP SIDE



BOTTOM SIDE

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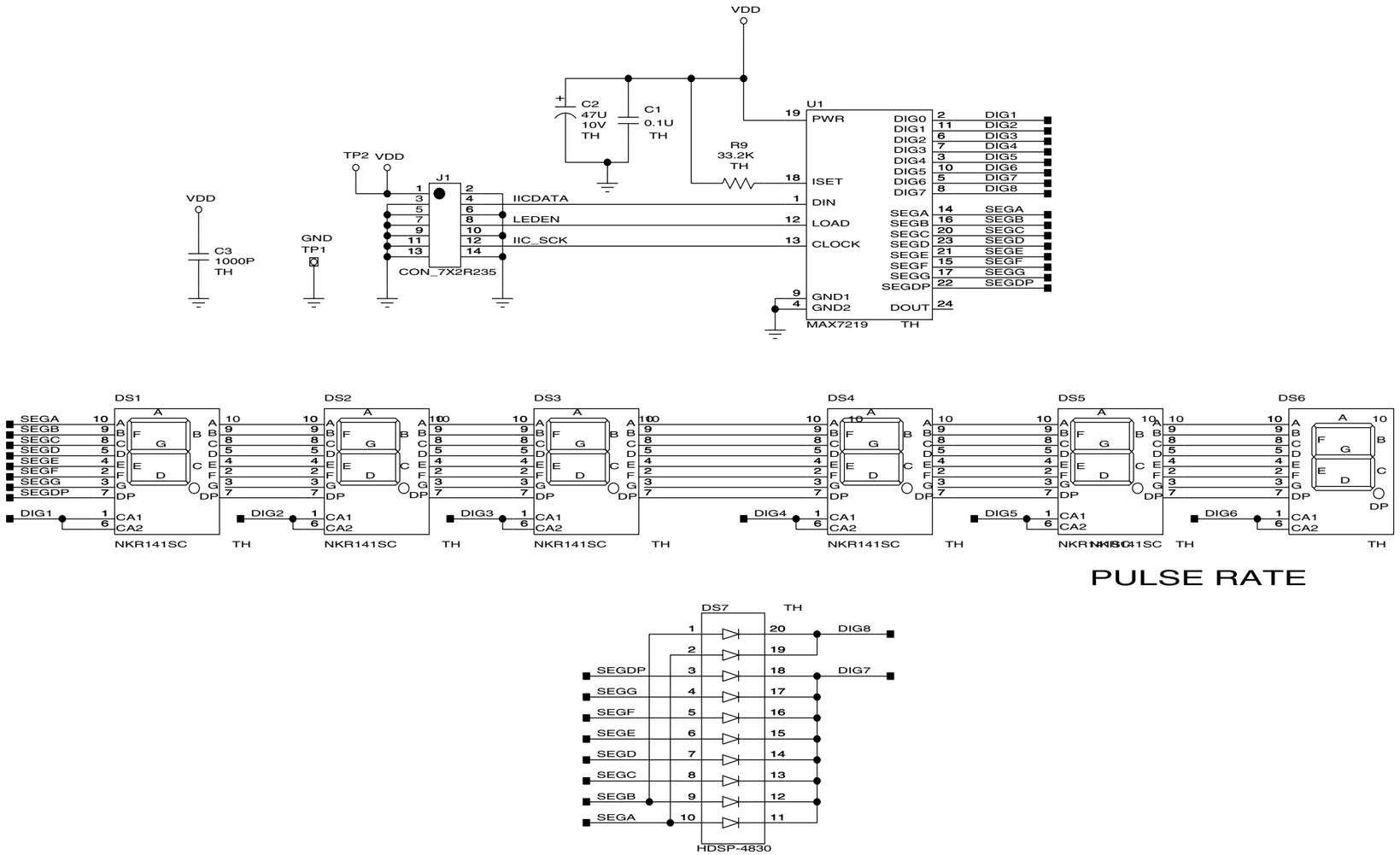
Figure S-12
Parts Locator Diagram for UIF PCB (10 of 10)



PULSE RATE

Figure S-13
Display PCB Schematic Diagram (1 of 2)

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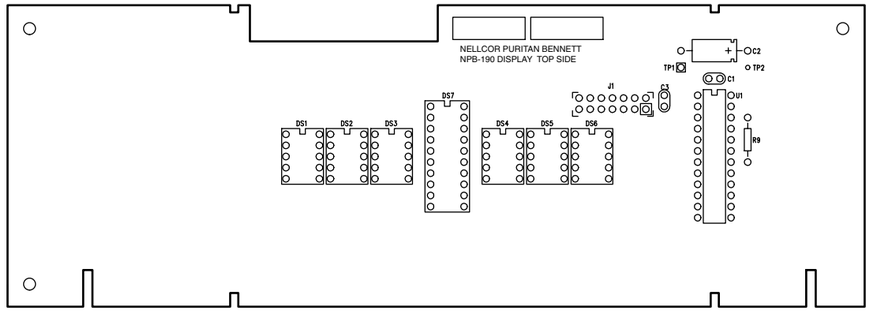

Figure S-14
Parts Locator Diagram for Display PCB (2 of 2)

035196

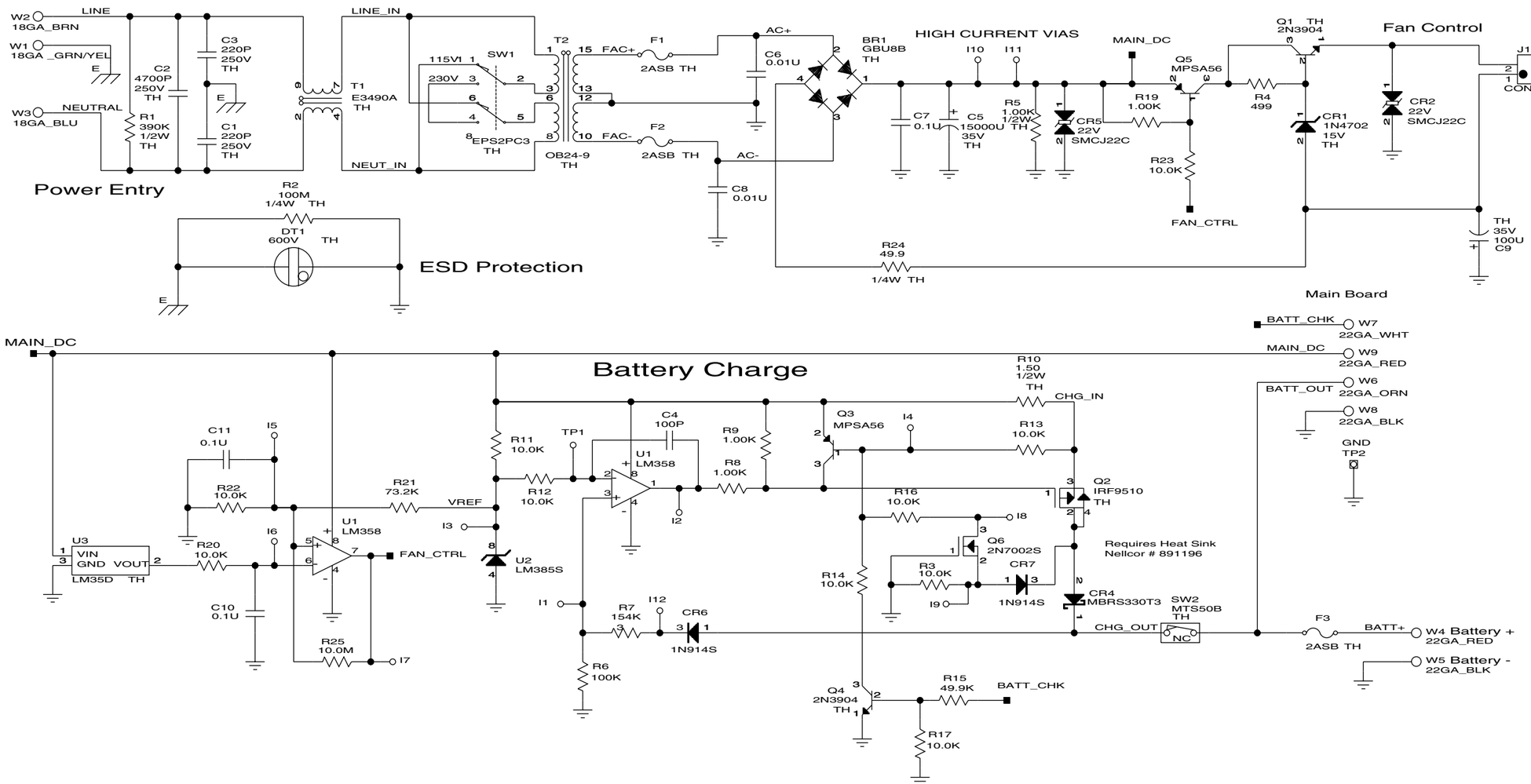

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Figure S-15
Power Supply Schematic Diagram (1 of 2)

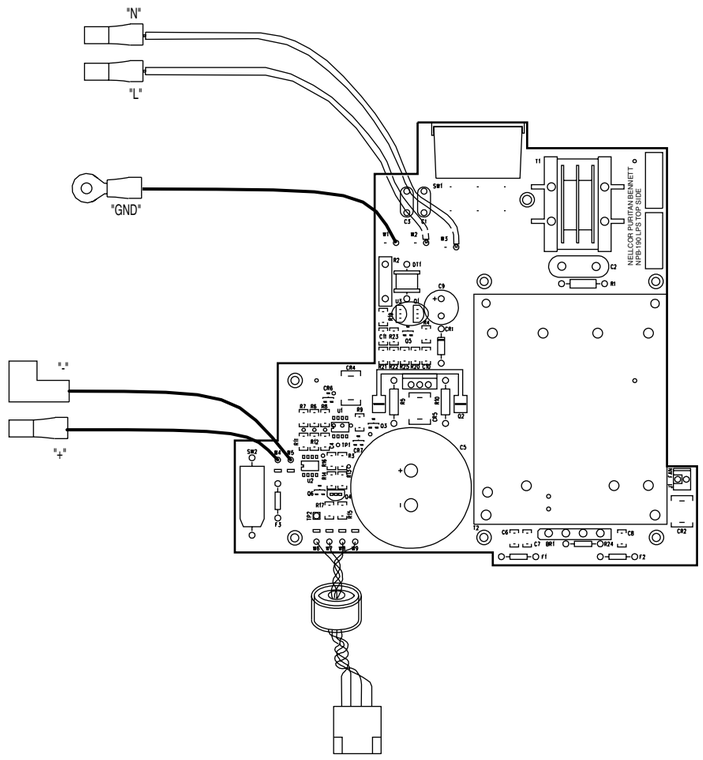

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Figure S-16
Parts Locator Diagram for Power Supply PCB (2 of 2)